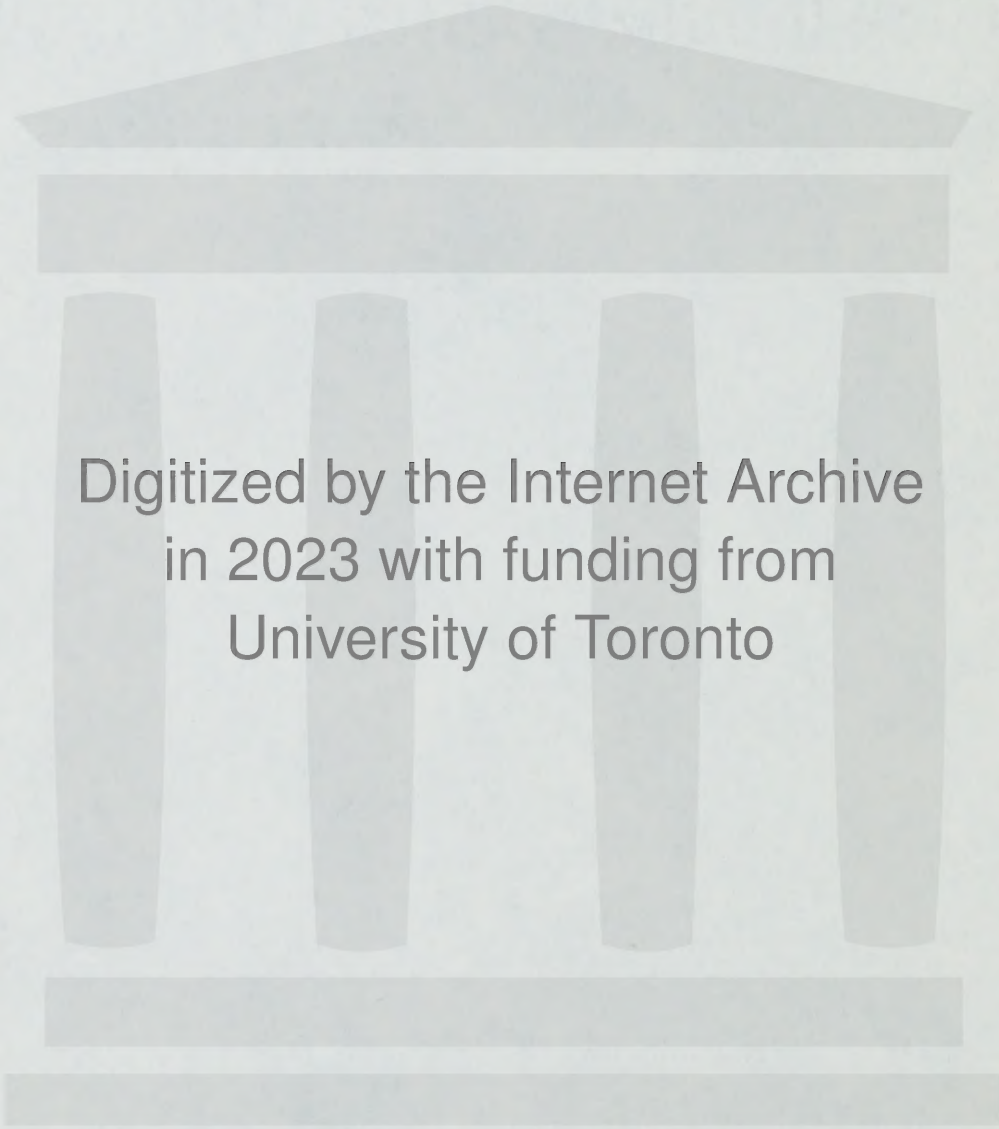
HYDRO-ELECTRIC INQUIRY COMMISSION

ENGINEERING DATA

THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

WALTER J. FRANCIS & COMPANY

CONSULTING ENGINEERS



HYDRO-ELECTRIC INQUIRY COMMISSION

ENGINEERING DATA

in regard to

THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

of

THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO

Walter J. Francis & Company

Consulting Engineers

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO MR. J. ALLAN ROSS.

Toronto, Ontario,

August 30th, 1923.

Hydro-Electric Inquiry Commission,
W. D. Gregory, Esq., Chairman,
T O R O N T O, Ontario.

re Engineering Data, The Queenston-Chippawa Power Development of the Hydro-Electric Power Commission of Ontario.

Mr. Chairman and Gentlemen:

In complying with your instructions, it gives me pleasure to forward herewith to your Secretary, Mr. J. H. W. Bower, the engineering data in regard to the Queenston-Chippawa Power Development of the Hydro-Electric Power Commission of Ontario, being the whole series of chapters which we have submitted to you from time to time during the course of preparation.

The economics of the Niagara System, of which the Queenston-Chippawa Power Development forms a part, is dealt with in two separate volumes under the titles: "Study of Niagara System, Part I, being for period ending October 31st, 1921" and "Study of Niagara System, Part II, being for period commencing November 1st, 1921", the former of which is dated June 15th, 1923, and the latter June 23rd, 1923.

I trust that the whole may be found in order.

Yours very truly,

Walter J. Francis

Consulting Engineer.

WJF/S

WALTER J. FRANCIS & COMPANY

COPY FOR ENCLOSURE TO MR. J. ALLAN ROSS.

Toronto, Ontario,

August 30th, 1923.

Hydro-Electric Inquiry Commission,
W. D. Gregory, Esq., Chairman,
TORONTO, Ontario.

re Engineering Data, The Queenston-Chippewa Power Development
of the Hydro-Electric Power Commission of Ontario.

Mr. Chairman and Gentlemen:

In complying with your instructions, it gives me pleasure to forward herewith to your Secretary, Mr. J. H. W. Bower, the engineering data in regard to the Queenston-Chippewa Power Development of the Hydro-Electric Power Commission of Ontario, being the whole series of chapters which we have submitted to you from time to time during the course of preparation.

The economics of the Niagara System, of which the Queenston-Chippewa Power Development forms a part, is dealt with in two separate volumes under the titles: "Study of Niagara System, Part I, being for period ending October 31st, 1921" and "Study of Niagara System, Part II, being for period commencing November 1st, 1921", the former of which is dated June 15th, 1923, and the latter June 23rd, 1923.

I trust that the whole may be found in order.

Yours very truly,

Consulting Engineer.

WJF/S

GENERAL INDEX.

G E N E R A L I N D E X.

Chapter A.

PREFACE

Walter J. Francis.

INDEX TO CHAPTER A.

Chapter A.

INTAKE

Walter J. Francis

The information embraced under the general title of "Engineering Data" in regard to the Queenston-Chippawa Power Development of the Hydro-Electric Power Commission of Ontario has been prepared under the direction of the writer in compliance with the instructions of the Hydro-Electric Inquiry Commission. The Engineering Data are confined solely to matters of engineering, and do not include questions of policy nor the relations of the Hydro-Electric Power Commission with the Government of the Province. Accountancy is dealt with in this study only in regard to estimates and costs. The preparation of the data was commenced in April, 1922, and has proceeded uninterruptedly until the present time in conjunction with the studies of the workings of the Hydro-Electric Power Commission.

The information has been formally submitted to the Hydro-Electric Inquiry Commission at intervals as prepared, following the decision reached at the commencement of the work. With each finished document were submitted the requisite number of practically facsimile working copies of the original for the use and study of the Hydro-Electric Inquiry Commission, together with a similar copy for the Chief Engineer of the Hydro-Electric Power Commission. The submissions were made in the sessions of the Hydro-Electric Inquiry

Commission at which the reports were read and discussed.

The facts have been obtained by reference to the records of the Hydro-Electric Power Commission, by conferences with the engineers and the officers of the Hydro-Electric Power Commission, by personal examination of the works, and by tests in the field and in the laboratories, and it is a pleasure to refer to the courteous co-operation of the Hydro-Electric Power Commission in our work. While there has been splendid co-operation on all sides, the assistance rendered by Mr. Gaby, by Mr. Acres, Mr. Hearn and Mr. Montague, by Mr. Hogg, by Mr. Blanchard, by Mr. Bradley, by Mr. Dobson and Mr. Young, and by Mr. Pierdon should be specially mentioned in referring to the engineers and officers of the Hydro-Electric Power Commission.

On May 1st, 1922, the writer made a memorandum for Mr. Rusfield outlining a plan for the preparation of the data. Having subsequently received the approval of the Hydro-Electric Inquiry Commission, this memorandum was adopted as a general guide for the preparation of the data. The plan outlined therein is as follows,-

The Queenston-Chippawa Power Development.

Historical:

Preliminary Considerations - Dates,
Immediate Power Needs,
Future Power Needs.
Design Period - - - - - - - Dates,
Studies,
Decisions.
Construction Period - - - - Dates,
Sequence of Operations.

(---3)

Commission at which the reports were read and discussed.

The facts have been obtained by reference to the records of the Electric Power Undertaking, by consultation with the engineers and the officers of the Hydro-Electric Power Commission, by personal examination of the works, and by tests in the field and in the laboratories, and it is a pleasure to refer to the courteous co-operation of the Hydro-Electric Power Commission in that work. Other data have been collected and kindly furnished by Dr. Haanel, Mr. Arthur, Mr. Davis and Mr. Anderson, of the Mines Branch of the Department, by Mr. Keeley of the Toronto and York Radial Railway Co., and by Mr. Nicholson who has also rendered valuable assistance in the engineering and clerical work of the Hydro-Electric Power Commission.

On May 1st, 1906, the writer made a memorandum for Mr. Merrill outlining a plan for the preparation of the data. During subsequent periods the approval of the Hydro-Electric Inquiry Commission was obtained as a general guide for the preparation of the data. The plan outlined therein is as follows,-

The Ontario-Ottawa Power Development.

Material.

Preliminary Considerations - Dates.
Immediate Power Needs.
Future Power Needs.
Dates.
Details.
Details.
Details of Operation.

Advisory Reports:

In General,
Recommendations Adopted,
Reports in Detail as Far as Necessary (as Appendix).

Power Available:

Elevations,
Flow,
Hydraulic Capacity of Various Elements of Development.

General Description:

Right-of-Way and Crossings,
Intake,
Welland River,
Canal,
Forebay,
Screen House,
Penstocks,
Power House
Tail Race.

(The Building,
(Turbines,
(Generators,
(Service Plant,
(Auxiliary Plant,
(Electrical Equipment,
(Accessories,
(Miscellaneous.

Organization:

Head Office - The Commission,
Queenston-Chippawa Power Development,
Personnel,
Records.
Field Office-
Personnel,
Records.
Superintendence -
Personnel,
Records.
Staff Relations in Detail.

Contract Work:

Invitation to Tender,
Contracts let.

Construction Plant:

Machinery, methods and direction of all plant used by force account, subdivided according to the basic elements of the development as set forth in the headings under "General Description", together with capacity and daily, minimum, maximum and average output of the more important machines.

Quantities:

Quantities of work done of every classification, subdivided according to the basic elements of the development as set forth in the headings under "General Description", together with capacity and daily, minimum, maximum and average output of the more important machines.

Costs:

Total cost of the work, completely defined. Cost of work done of every classification, subdivided according to the basic elements of the development as set forth in the headings under "General Description".
Unit costs of work done of every classification.

Evolution of the Development:

Full information regarding estimates, revisions and changes made from time to time, in detail.

Comparisons of Various Main Estimates and Actual Cost:

Discussions:

Quality of Work,
Speed of Construction,
Exigencies of Period of Construction,
Labor market and inefficiency,
War prices,
Market generally,
War taxes,
Exchange and so forth,
General Design,
Unit Costs,
General,
The Outlook.

In pursuing our studies some minor departures were made from the memorandum, but it has been followed in the main, as will be seen by reference to the General Index. A supplementary volume entitled "Chronological Charts", being a yearly diagrammatic record of the principal events and features of construction arranged according to the several elements of the development in chronological

Quantities:

Quantities of each item of every classification, applied separately to the basic elements of the development as set forth in the heading number "General Description", together with capacity and daily, minimum, maximum and average output of the more important operations.

Costs:

Total cost of the work heretofore defined, cost of each done of every classification, subdivided according to the basic elements of the development as set forth in the headings under "General Description".
Unit costs of work done of every classification.

Illustrations:

Duplicate
Index
Legend
Maps
Plans
Profiles
Sections
Views

order by months, was found of considerable value in our studies, and was subsequently adopted for inclusion with the Data. The subject of the economics of the Queenston-Chippawa Power Development is dealt with separately under the general title "Economics of the Hydro-Electric Power Commission Distribution Systems - Study of Niagara System", being a comprehensive study of the economics of the Niagara System more particularly in regard to generation, transmission and market.

In connection with the financial data, we have by instructions co-operated with Messrs. Price, Waterhouse & Co., represented by Mr. McClelland, Mr. Bonthron and Mr. Landis, and with Mr. Greacy and Mr. Brown of their staff, the assistance and hearty co-operation of all of whom have been much appreciated.

The internal arrangement of our staff work was modified from time to time as the demands arose. Mr. Busfield was in charge of the office work until September, 1922. Later the drafting was directed in turn by Mr. Hirsch and by Mr. Adams, with Mr. Arnson giving his special attention to the photography and document making. Miss M. Scafe took charge of the secretarial and the typographical work in September, 1922. The preliminary cost studies were carried on by Mr. Wilgar, and were concluded by Mr. Wilson. The railways studies were made by Mr. Hirsch, followed by Mr. Abbott who later took up the study of the bridges also. Mr. Ellis carried on the hydraulic studies. The concluding studies in regard to hydraulics and expenditure were made by Mr. Brown on the completion of his detail work on the economics of the several distribution systems of the Hydro-Electric Power Commission. The time of Mr. Billson,

(3-B)

Mr. McDonald and Mr. Williams was devoted to drafting. The writer's undivided attention has been devoted to the collection, co-ordination, compilation, study and preparation of the Data from the beginning, and he desires to acknowledge the painstaking ability, the enthusiastic interest and the loyalty of every member of our staff. As a matter of record the professional standing of the staff engineers engaged on the preparation of the Engineering Data of the Queenston-Chippawa Power Development is here given.

Capt. W. H. Abbott, M.C., (McGill University),
Associate Member, The Engineering Institute of Canada.
Fifteen years' experience in electrical work and construction.

Major W. D. Adams, M.C., Graduate, Royal Military College,
Associate Member, The Engineering Institute of Canada,
Member, Association of Professional Engineers of the Province of Ontario.
Eighteen years' experience in design and construction.

H. P. Armson,
Associate Member, The Engineering Institute of Canada.
Eighteen years' experience in machine design and drafting.

George E. Billson,
Eleven years' experience in construction and drafting.

Frederick B. Brown, B.Sc., B.Sc., and M.Sc., (McGill University),
Life Member, The Engineering Institute of Canada,
Member, American Institute of Electrical Engineers,
Member, American Society of Mechanical Engineers.
Twenty-four years' experience largely in hydro-electric work and in engineering economics.

J. L. Busfield, B.Sc. with honours, (London, England, University),
A.C.G.I., (Central Technical College, London, England),
Member, The Engineering Institute of Canada,
Associate Member, Institution of Civil Engineers, Great Britain.
Fifteen years' experience in railroad construction, tunnel work, Government investigations and consulting work.

Lt. Col. Douglas S. Ellis, D.S.C., M.A., (Queen's University),
B.Sc. (Queen's University),
M.E. (Cornell University),
Associate Member, The Engineering Institute of Canada,
Associate Professor of Civil Engineering (Hydraulics) at Queen's University, Kingston.
Fifteen years' experience in hydraulic work and surveying.

Walter J. Francis, C.E., (University of Toronto),
Honor Graduate School of Practical Science, 1893,
Life Member, The Engineering Institute of Canada,
Member, American Society of Civil Engineers,
Member, Institution of Civil Engineers, Great Britain,
Charter Member, American Institute of Consulting Engineers, Inc.
Thirty-three years' engineering experience.

Lynn I. Hirsch,
Associate Member, The Engineering Institute of Canada,
Member, American Association of Engineers.
Twenty-one years' experience in railway and construction engineering.

C. K. McDonald,
Sixteen years' experience in construction and drafting.

J. B. Walcot, D.L.S.,
Associate Member, The Engineering Institute of Canada,
Twelve years' experience in construction and report work.

Lt. Col. W. P. Wilgar, D.S.O., B.Sc. (Queen's University),
Member, The Engineering Institute of Canada,
Professor of Civil Engineering at Queen's University, Kingston.
Twenty-two years' experience in railway and municipal engineering.

S. R. Williams,
Seventeen years' experience in mechanical work, map making and drafting.

W. S. Wilson, B.Sc., (McGill University),
Associate Member, The Engineering Institute of Canada,
Member, Association of Professional Engineers of the Province of Ontario.
Nineteen years' experience in construction and maintenance.

We desire to express our appreciation of the unfailing attention, assistance and courtesy of Mr. J. H. W. Bower, Secretary of the Hydro-Electric Inquiry

Commission, in co-relating our work with that of the Hydro-Electric Inquiry Commission and in co-operating in our routine and business records, which added greatly to its expeditious completion.

Throughout our investigations we have received the interested support of the Chairman and the other members of the Hydro-Electric Inquiry Commission, completing the cordial relations which have existed during the whole progress of an arduous but most interesting study.

Walter J. Francis
Consulting Engineer.

Toronto, August 22nd, 1923.

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Chapter B.

HISTORY

Walter J. Francis.

INDEX TO CHAPTER B.

COPY FOR ENCLOSURE TO MR. J. ALLAN ROSS.

(B-Index)

INDEX TO DRAWING B.

Subject	Page
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Chapter B.

HISTORY

Walter J. Francis

For a number of years, and prior to any detail investigation of the project which is now known as the Queenston-Chippawa Power Development, the engineers of the Hydro-Electric Power Commission of Ontario appreciated the ultimate necessity of utilizing all the water available from Niagara Falls in the most efficient way possible. The permissible amount of water divertable from the river by treaty being limited in quantity, the engineers considered it essential that this water should be converted into electrical energy under the greatest head possible. In the past the plants developing electrical power at Niagara were using only the head available immediately at the Falls, whereas between Lake Erie and Lake Ontario there is a difference in elevation of about twice that amount. The problem resolved itself into the determination of the best plan to take advantage of this greater head.

As early as the year 1900 a number of independent engineers had conceived various projects for developing the water from Niagara Falls under a greater proportion of the total head between Lake Erie and Lake Ontario than had hitherto been considered. Some of these projects proposed bringing the water from Lake Erie across the Niagara Peninsula by means of the existing waterways and artificial canals at a location some miles west of the Niagara River,

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Walter J. Francis

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with a power house located in the vicinity of the Village of Jordan. These projects were variously known as the Jordan-Erie project and the Erie-Ontario project. Still other projects were based upon a form of development closer to the Niagara River.

By the year 1913 the engineers of the Hydro-Electric Power Commission decided that the time had arrived when definite steps would have to be taken to provide a larger supply of power for the Niagara System. It was therefore decided to give more attention to the study of the relative merits of the different methods of developing under the maximum possible head the available flow that might be withdrawn from Niagara Falls. To this end a reconnaissance survey for the Queenston-Chippawa Power Development was started on May 4th, 1914, and during the same month level and transit parties were also placed in the field. This survey was carried out during the year 1914, the engineers occupying a temporary office at Niagara Falls. Early in 1915 the temporary office was closed and the staff taken to Toronto. The preparation of a complete topographical plan was then commenced. This plan was completed on March 1st, 1915.

Coincident with this work, a survey of the suggested "Jordan-Erie" method of development was also undertaken in order that a proper comparison might be made between the various projects. The "Jordan-Erie" survey was completed on October 7th, 1914.

In order to obtain definite data regarding the location of the rock surface throughout the length of the Queenston-Chippawa Power Canal, a core drill commenced working on October 26th, 1914, and made borings continuously until

September 15th, 1915.

With the aid of the data so obtained, sketches of preliminary designs were prepared for a development of 100,000 horsepower, and in June, 1915, an estimate of cost, known as Estimate No. 1, was submitted to the Commission. The engineers of the Hydro-Electric Power Commission state that this estimate was always of a preliminary nature and was prepared solely as a justification for the continuance of the surveys.

Additional survey work was thereupon approved, and on June 21st, 1915, field work was re-commenced with particular reference to the details of cross sections and topography.

The first Act of the Ontario Legislature empowering the Hydro-Electric Power Commission to proceed with the construction of the Queenston-Chippawa Power Development was assented to on April 27th, 1916, and was entitled "The Ontario Niagara Development Act" (6 Geo.V. Chap.20). A second Act, enlarging upon the first, and entitled "The Ontario Niagara Development Act 1917" (7 Geo.V. Chap.21) was assented to on April 12th, 1917.

During the year 1916 the surveys and detail studies for designs were carried on continuously with the requisite field and office staff. In the summer of the same year well-drilling was carried on for the purpose of supplementing the core drill records and of obtaining exact information regarding the stratification and nature of the underlying rock throughout the canal and power house location. In the fall of 1916 the field parties devoted their time to the surveys for the construction railway.

As a result of the studies made during the year 1916, orders were placed for a large quantity of construction equipment, most of which was delivered

during the latter part of 1917.

The first excavation was commenced with No. 7 steam shovel in May of 1917, at Bowman's Gully, opposite the whirlpool. On June 1st, 1917, the second steam shovel (No. 5) was put to work for the construction of the railroad yards. On September 29th, 1917, the clearing of the power house site was started. On November 17th, a third steam shovel (No. 6) commenced the construction railroad cut, and on December 15th, the first electric shovel (No. 3) began on the main canal excavation.

On December 26th, 1917, a general report was prepared and submitted by Mr. H. G. Acres, Hydraulic Engineer of the Hydro-Electric Power Commission, covering the various studies which had been made for the development, together with detailed descriptions of the proposed construction equipment and organization. With this report there was also submitted Estimate No. 2 for 300,000 horsepower installed capacity.

On February 1st, 1917, a report was made on the hydraulic characteristics of the rock section of the power canal by Mr. R. D. Johnson, hydraulic engineer, of New York. This report was followed by a second one, dated April, 1917, by the same author, dealing with comparative waterways for the development of 900,000 horsepower.

During the year 1918 additional construction equipment was placed in commission, and the work became well under way throughout the whole of the undertaking, including the river, the canal and the whirlpool sections, and the power house.

During the latter part of 1917 and early in 1918, on account of war conditions, power supply was considered of vital necessity; and in May of 1918,

at the suggestion of the Power Controller of the United States, conferences were held between officers of the Hydro-Electric Power Commission and the Power Controller of the United States to consider the possibility of completing the Queenston-Chippawa Power Development within a year from that date. In July of 1918 improved conditions at the Front led to the abandonment of the suggested attempt to rush the work to completion at any cost. Consequently, during the years 1918 and 1919, the work progressed comparatively slowly, largely on account of the shortage of labor; and it is stated to have been found almost impossible to obtain anything like the requisite number of men to carry out the work efficiently.

During the summer of 1918 special attention was given to the studies for the intake design. A model of a section of the Niagara River was built in the Dufferin Island Channel, and a series of experiments made to determine the best type of intake. The experiments carried out during 1918 were not entirely conclusive, and a second series of experiments was made during the summer of the year 1919. Independent advice was also obtained from Mr. R. D. Johnson who made two reports thereon, one on January 31st, 1919, and a second on March 1st, 1920.

The excavation of rock on the cliff over the power house site was commenced on April 12th, 1919. During April, May and June of the same year three additional electric shovels were put to work in the canal cut. On August 26th the first concrete was placed for the canal lining at the "transition" between the whirlpool and rock sections.

In order to provide access to the power house site, excavation was commenced for a railway along the base of the cliff leading from Queenston to the site of the building, in July, 1919, and five months later a steam shovel

was started on the power house excavation.

During the early part of 1920 work was continued under very unsatisfactory labor conditions which in May, 1920, culminated in a strike of all labor forces, with the exception of the train men. A parliamentary commission, under the chairmanship of Mr. Edgar Watson, M.P.P., was appointed by the Lieutenant-Governor-in-Council on May 19, 1920. After due inquiry, this Commission reported to the Lieutenant-Governor on June 4, 1920. The strike remained in effect until July, 1920, and an attempt was then made to make up for lost time by placing the work on a rush schedule. During the later months of the year, additional equipment was introduced, and the concrete canal lining was commenced. On November 8th the first concrete for the power house was placed. At the screen house the first concrete plant commenced work on February 21st, 1921. Dredging proceeded in the earth section from March to September, 1921, and in the canal section the excavation was completed by November, 1921.

During the year 1920 a number of reports were obtained from consulting engineers on various phases of the development. These were as follows:-

June 1st, 1920, General Report by R. D. Johnson,

August 7th, 1920, Preliminary Report by Hugh L. Cooper & Company, with Estimate of Cost,

September 30th, 1920, General Report by Francis Lee Stuart and H. S. Kerbaugh,

October 18th, 1920, General Report by P. A. Schoellkopf,

October 22nd, 1920, Final Report by Hugh L. Cooper & Company,

October 26th, 1920, Report on Power Canal by R. S. Lea.

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No advisory reports were obtained from consulting engineers during 1921 with the exception of a Progress Report by Francis Lee Stuart, dated December 13th, 1921.

By December 21st, 1921, the concrete canal lining was completed and the water was first turned into the canal at 4.25 a.m. on December 24th. The official opening of the plant took place on December 28th, 1921, at which ceremony the No.1 main generating unit was first put into commission.

The No.2 generating unit was being installed at the same time as No. 1 unit, and was first tried out by the contractors in April, 1922, but some days later, while still in the hands of the contractors, a minor defect developed in a detail of the ventilating equipment and the machine was closed down for repairs from the middle of April, 1922, until late in May, 1922. Unit No.2 was finally placed in commission along with Unit No.1 on June 1st, 1922.

The condition of the work at the present date, June 30th, 1922, may be briefly summarised as follows:-

The Intake: Main excavation completed; contract let for concrete structure.

The Welland River: Excavation practically complete for five units, except near canal; dredging contract let for completion of work.

The Canal: Practically completed with the exception of trimming and dressing the banks, and some rock fill on the sides. In the earth section, some additional excavation work is required, and the dredging contract for this has been let.

The Forebay: Completed, with the exception of a small amount of rock fill at the back of the retaining walls, and some grading for the spillway.

The Screen House: In progress of completion for five units; sub-structure

complete for nine units.

The Power House: Units Nos. 1 and 2 complete and in operation; Unit No. 3, the electric generator is being installed; Unit No. 4, the turbine is being installed; Unit No. 5, the foundations are being prepared for the installation of the turbine; Unit No. 6, some excavation has been done for the penstock; Units Nos. 7, 8 and 9, some clearing and a small amount of excavation has been done.

The Power House building and the electrical equipment is in progress and in various degrees of completion corresponding to the installation of the units.

Bridges: The railroad bridges and the highway bridge at Chippawa are completed, while the remaining highway bridges are under various stages of consideration.

General Work: The work is generally progressing towards completion, with the retention of such construction forces and commissariat as necessary, while at the same time salvage work is being carried on with particular reference to such scrap material as pipes and fittings, rails and fastenings, timber and mechanical equipment.

Walter J. Francis
Consulting Engineer.

Toronto, July 13th, 1922.

Chapter C.

ADVISORY REPORTS

Walter J. Francis.

INDEX TO CHAPTER C.

(C-Index)

INDEX TO CHAPTER C.

Subject | Page

Chapter C.

ADVISORY REPORTS

Walter J. Francis

During the period of design and, later, during that of construction the Hydro-Electric Power Commission obtained the advice of a number of consulting engineers of Canada and of the United States on various phases of the development. The following table gives a complete list of the reports placed in the chronological order of submission to the Commission.

List of Advisory Reports.

Date	Subject	Authors
February 1, 1917.	"Hydraulic characteristics of rock section of power canal".	R. D. Johnson.
April, 1917.	"Report on comparative waterways for development of 900,000 horsepower".	R. D. Johnson.
September 19, 1917, and September 24, 1917.	"Probable cost of rock and earth excavation, with letters from Hugh L. Cooper and Company, F. McGovern and Company, and The Rapid Transit Subway Construction Company".	A. C. Douglass.
July 30, 1918.	"Study of (1) Canal Bends, (2) Ice Skimmer and (3) Canal Losses".	R. D. Johnson.

Date	Subject	Author
July 30, 1918.	"Study of (1) Canal Banks, (2) Ice Skimmer and (3) Canal Losses".	R. D. Johnson.
	"Report on Construction Company".	Y. C. Douglass.
September 14, 1917.	Book I. Canyon and Overpass, Excavation, with Letters from Consulting Engineer and Contractor.	
September 19, 1917.	"Probable cost of rock and earth excavation, with letters from Consulting Engineer and Contractor".	
	horsepower".	E. D. Johnson.
Sept. 12, 1917.	"Report on exploratory work for power development at Doe Dam	
February 5, 1917.	"Geneville Electric Light & Power Co. section of power canal".	E. D. Johnson.

List of Advisory Reports (Cont'd--#2).

Date.	Subject.	Authors.
January 31, 1919.	"Study of Intake for 15,000 Cubic Feet per Second".	R. D. Johnson.
March 1, 1920.	"Design of Intake for 15,000 Cubic Feet per Second".	R. D. Johnson.
June 1, 1920.	"Report on Queenston-Chippawa Development".	R. D. Johnson.
August 7, 1920.	"Report on Chippawa Hydro-Electric Project". (Letter of Transmittal and Cost Estimates).	Hugh L. Cooper & Company.
September 30, 1920.	"Report on Chippawa Development".	Francis L. Stuart and H. S. Kerbaugh.
October 18, 1920.	"Report on Elevation of Chippawa Pool".	P. A. Schoellkopf.
October 22, 1920.	"Final Report".	Hugh L. Cooper & Company.
October 26, 1920.	"Report on Power Canal of Queenston-Chippawa Power Development".	R. S. Lea.
December 13, 1921.	"Report on Progress".	Francis L. Stuart and H. S. Kerbaugh.

These reports have all been carefully studied and analyzed, and the following pages contain a summary and digest of each report.

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[illegible]	[illegible]	[illegible]

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Hydraulic Characteristics of Rock Section of Power Canal.

R. D. Johnson.

A report dated February 1st, 1917, signed by R. D. Johnson, of R. D. Johnson and P. Wahlman, hydraulic engineers, of New York, was addressed to Frederick A. Gaby, Chief Engineer of the Hydro-Electric Power Commission.

Mr. Johnson was born in Buffalo, N.Y., in 1874, and graduated in Mechanical Engineering from Buffalo University in 1895, since which date practically his entire time has been devoted to problems connected with the development of water power.

He commenced his engineering activities at Niagara Falls in connection with various power installations, following which he became Resident Engineer in charge of the design and construction of the first plant built by the Shawinigan Water & Power Company, at Shawinigan Falls, Quebec. On the completion of this work he was connected with the construction of the Municipal Water Power Development at Winnipeg. Mr. Johnson then accepted the position of Designing Engineer with the Ontario Power Company, at Niagara Falls, and later became Hydraulic Engineer. He remained with the Ontario Power Company until 1914, with the exception of the period from 1902 to 1905, when he occupied the position of Designing Engineer for the New York State Water Supply Commission.

Mr. Johnson left the Ontario Power Company to take up private practice in New York, as a consulting hydraulic engineer, and in this capacity carried out considerable advisory work for the Niagara Falls Power Company and the

Hydro-Electric Power Commission of Ontario. His name is known throughout the engineering world as the inventor of the Johnson Valve and of the Differential Surge Tank.

He is a member of the American Society of Mechanical Engineers.

The report states that it was made in accordance with verbal instructions given by Mr. Saby on October 3rd, 1916, to take under consideration the methods adopted by the assistant engineers of the Hydro-Electric Power Commission to determine the economical dimensions of the proposed power canal to carry 6,850 cubic feet per second of water from the Chippawa River to a point above Queenston.

The original report consists of thirty-two pages of typewriting, accompanied by forty-seven numbered diagrams, entitled "Economy Studies, Rock Canal 37,000 Feet Long". It is divided into the following main headings:-

Questions Affecting Economical Dimensions,

Some Broader Considerations Affecting a Choice of Cross-Section,

Coefficients of Friction,

Effect of Variation in Water Levels upon the Economy Studies,

Method of Determining the Composite Economical Cuts for the Two Sections, (Earth and Rock),

General Description of the Course of Study Leading to a Recommendation of Dimensions to be Adopted for the Rock Section of Canal,

Surges.

Mr. Johnson generally approves of the designs prepared by the engineers of the Hydro-Electric Power Commission.

COPY

In pursuing his studies the author states that his calculations have been based on a unit price of $1.25 per cubic yard for rock excavation, which he later reduced to $1.00, while for earth excavation he used 30 cents per cubic yard. A canal flow of 6,550 cubic feet per second was used as a basis for the studies.

The author discusses the theory that if the increasing of the canal section would provide additional power output at the plant, the necessary additional excavation might be warranted, notwithstanding the fact that the capital cost of such additional power might be greater per unit than the average capital cost per unit of the whole development. He does not, however, make a definite recommendation in this regard.

Continuing, the author deals with the hydraulic characteristics of various canal sections, and recommends that instead of using a proportion of width to depth of 2 to 1, as already selected by the engineers of the Hydro-Electric Power Commission, the proportions be made 1 to 1; that is, the width of the canal equal to the depth. In addition, he states that in his judgment, following suggestions received from the manufacturers of excavating machinery, the minimum width of the canal should be 40 feet.

In referring to the level of the water of the "Chippawa pool", (the upper level of the development), Mr. Johnson expresses the view that elevation 555 should be adopted for calculation purposes rather than 560.5 as used by the engineers of the Hydro-Electric Power Commission.

The author made a careful study of the possible unstable conditions of the water surface in the canal due to sudden changes of load at the power house. He arrived at the conclusion that the sudden closing down of the

turbines would result in a temporary rise of the water level in the forebay at the lower end of the canal of about 3 feet above the existing river level, and he recommends provision for a rise of 6 feet above the maximum level of the "Chippawa pool".

Report on Comparative Waterways for Development of 900,000 Horsepower.

R. D. Johnson.

A report dated April 18th, 1917, signed by R. D. Johnson, of R. D. Johnson and P. Wahlman, hydraulic engineers, of New York, was addressed to Frederick A. Gaby, Chief Engineer of the Hydro-Electric Power Commission, Toronto.

Mr. Johnson's engineering qualifications have already been given on pages C-3 and C-4.

The original report consists of seven pages of typewriting, together with four pages of estimates and eleven sheets of sketches showing the types of construction upon which the estimates have been based.

The report was made in accordance with verbal instructions from Mr. Gaby given on February 21st, 1917, supplemented by a letter under date of March 8th, 1917, as follows:-

(Letterhead of Hydro-Electric Power Commission)

"TORONTO, March 8th, 1917.
H.G.A.

R. D. Johnson, Esq.,
Consulting Engineer,
60 Wall Street,
NEW YORK CITY.

Dear Sir:-

Re Niagara Development.

"Pursuant to our recent interview, and in response to your letter of February 27th, I am setting forth hereunder a

summary of requirements of the general report you have been asked to make in connection with the proposed Niagara Development scheme.

"The primary requirement is the preparation of comparative estimates covering the cost of developing and delivering to the low tension switchboard quantities of power from 300,000 to 900,000 horsepower, by the use of a tunnel or tunnels, and by the use of a canal, giving due consideration to the value of any difference in head loss, and giving proper weight to the data upon which the respective estimates are based.

"As bearing upon the relative merits of the canal and tunnel scheme of development, we would also ask you to discuss the following propositions:-

(1) "Which of the two possible schemes of development would ensure the more economical and effective development of the 200,000 horsepower now considered available?

(2) "In the event of the canal scheme of development being adopted for the 200,000 horsepower now available, would such method of use render impracticable the adoption of the tunnel scheme for the development of the remaining 700,000 horsepower, assuming in this case, of course, that the tunnel scheme has been proved superior to the canal scheme on its merits?

(3) "Would the comparative economics of the two schemes of development be materially affected by the three foot increase in the minimum level of the Chippawa-Grass Island Pool which would result from the construction of the regulating weir proposed by the International Waterways Commission?

(4) "Would the comparative economics of the two schemes of development be materially affected by the certainty of ultimately being able, under the canal scheme, to draw 2,500 to 3,000 second feet (over and above permissible diversion from river) from the summit level of the Welland Canal at Montrose?

(5) "Could the possibility of using the summit level of the Welland Canal as a source of emergency water supply during periods of acute or abnormal ice trouble in the Niagara River be considered as a material advantage accruing to the canal scheme of development?

(6) "Would the possibility of ultimately drawing 6,500 second feet of water from the summit level of the Welland Canal, and raising the quiescent level in the power canal to elevation 570, be considered a material factor in favor of the canal scheme of development for the use of the 6,500 second feet now available from the river?

(7) "Assuming that power ultimately became so valuable as to render it necessary in the public interest to develop to the extreme limit of available head by a direct connection to Lake Erie level, could the tunnel scheme of development be adapted to such use?

(8) "How would the assumption that the ultimate governing factor of the problem is the conservation of head to the extreme limit of physical practicability affect the comparative economics of the tunnel and canal scheme of development?

"In order that there may be a clear understanding in connection with all matters to be covered by your report, it might be well for you to come to Toronto for the purpose of discussing the various points involved before you put your report in final shape.

"The material asked for in your letter of Feb. 27th, is being forwarded, together with some information relative thereto, which may be of value to you."

Yours truly,

HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO.

(signed) "F. A. Gaby"
Chief Engineer."

The report discusses ways and means of developing 900,000 horsepower at Niagara Falls with particular reference to a choice of waterways as between canals and tunnels. The author suggests that in the case of a canal proposal, the first canal to be undertaken should have a capacity of 10,000 cubic feet per second instead of 6,550 as hitherto contemplated.

The author compares the cost of construction of three canals, each with

a capacity of 10,000 cubic feet per second, with three pressure tunnels, each 37 feet in diameter having a combined capacity of 30,000 cubic feet per second. He concludes that his studies are sufficient to warrant the adoption of the tunnel type of development, but suggests that some further study might profitably be made upon the question of the most economical diameter to adopt for the first pressure tunnel to be undertaken.

Mr. Johnson submits the following estimates of cost for the canal and tunnel projects, both exclusive of features common to either project, such as the forebay, penstocks, intakes, surge chamber, distributor, and so forth:-

Canal, 67,700 ft. long, 10,000 cu. ft. per sec.....$17,039,810.00

Canal, 67,700 ft. long, 6,550 cu. ft. per sec.....$13,621,860.00

Second Canal, 67,700 ft. long, 10,000 cu. ft. per sec.....$16,010,360.00

Tunnel, 42,000 ft. long, 32 ft. diam., 6,550 cu. ft. per sec.....$11,790,000.00

Tunnel, 42,000 ft. long, 37 ft. diam., 10,000 cu. ft. per sec.....$14,962,500.00

Following this report there appears "Notes on R. D. Johnson's Report of April 18th, 1917". The authorship of these notes is not stated, but it is a complete refutation of Mr. Johnson's arguments, prepared by the engineers of the Hydro-Electric Power Commission.

Probable Cost of Tunnel Construction and of Earth and Rock Excavation.

A. C. Douglass.

A report, dated September 19th, 1917, was made on the probable cost of tunnel construction, and another, dated September 24th, 1917, was made on the probable cost of earth and rock excavation. Both reports were signed by A. C. Douglass, Mining Engineer and General Contractor, Niagara Falls, N. Y., and were addressed to Mr. F. A. Gaby, Chief Engineer, Hydro-Electric Power Commission.

Mr. Douglass was born near Ingersoll, Ont., in 1857, and was elected an Affiliate of the American Society of Civil Engineers in 1895. He is a mining engineer and general contractor of long experience on extensive construction work. Amongst the projects in connection with which he has had important responsibility, the following may be mentioned as being of particular interest as indicating Mr. Douglass's competence to express an opinion in regard to the projected canal or tunnel, - power tunnels and canals for the Niagara Falls Power Co., Niagara Falls, N. Y.; tail-race tunnel for the International Paper Co., Niagara Falls, N. Y.; tail-race tunnel of Canadian Niagara Power Co., and of Electrical Development Co., Niagara Falls, Ont.; double-track railroad tunnel at Hoboken, N. J.

The original of the report of September 19th contains eight pages of typewriting, and that of September 24th, four pages.

In the first report the author discusses the tunnel location and briefly outlines the methods of construction upon which his estimates are based. He divides the proposed tunnel into three sections, namely -

Type 1. A Tunnel 57 feet inside diameter, with concrete and no timber lining, for 21,000 feet,

Type 2. A Tunnel 57 feet inside diameter, with timber and concrete lining, for 10,500 feet,

Type 3. A Twin Tunnel, each 26 feet inside diameter, with timber and concrete lining, for 10,500 feet.

Mr. Douglass's estimate of cost for a tunnel of the above types is as follows:-

21,000 feet of type 1 at $276.01.....	$ 5,796,210
10,500 feet of type 2 at $347.06.....	$ 3,644,130
10,500 feet of type 3 at $433.64.....	$ 4,553,220
Special work at Whirlpool Gorge.....	$ 100,000
Total.....	$14,093,560

The author adds that the hydraulic losses would in all probability exceed those in an open canal for the same discharge, and also that 15 per cent should be added to the above estimate if it were deemed advisable to let the work by contract.

In his report of September 24th, 1917, Mr. Douglass states that he has studied the plans and that in regard to rock work he is of the opinion that,

(1) the cost of channelling should not exceed $0.27 per square foot,

(2) the cost of drilling should not exceed $0.10 per cubic yard,

(3) the cost of explosives should not exceed $0.30 per cubic yard,

(4) the cost of hoisting and loading should not exceed $0.10 per cubic yard,

(5) the cost of disposal should not exceed $0.10 per cubic yard, including extra yardage in open cut work, and

(6) the cost of rock excavation, including a reasonable allowance for pumping and baling, will not exceed $1.25 per cubic yard. By allowing 25 per cent for contingencies, he arrives at a total cost for rock excavation of $1.56 per cubic yard.

The author states that earth excavation, including all charges for disposal and so forth, should not exceed $0.35 per cubic yard.

Through the earth section where concrete lining is required, the author is of the opinion that $6.50 would be a reasonable price for concrete.

Finally he states that the dredging of the Welland River should not cost more than $0.20 per cubic yard as the American Government is doing similar work for $0.15 and $0.17 per cubic yard.

Mr. Douglass draws attention to the difficulty there will be of obtaining such skilled labor as channel-runners, drill-runners, dredge men, steam-shovel engineers and blacksmiths, and recommends that special arrangements be made with the Immigration authorities so that these classes of labor may be brought in from the United States.

Attached to the two reports referred to above, is a letter from George Perrine, Assistant Tunnel Engineer of The Rapid Transit Subway Construction Company, of New York, dated October 15th, 1917, and addressed to A. C. Douglass. Attached to the letter is the following estimate for the proposed tunnel suggested by Mr. Douglass:-

COPY

(1) 21,000 feet of type 1 at $303.41.....$ 6,371,610

(2) 10,500 feet of type 2 at $412.16.....$ 4,327,680

(3) 10,500 feet of type 3 at $466.45.....$ 4,897,725

Special work at Whirlpool Gorge.....$ 100,000

Total.....$15,697,015

Mr. Perrine estimated the excavation costs as follows:-

Earth excavation.....$0.35 per cubic yard,

Rock excavation.....$1.75 per cubic yard,

Hydraulic dredging.....$0.20 per cubic yard,

Concrete in canal.....$6.50 per cubic yard.

There is also a letter attached to the two reports signed by Hugh L. Cooper & Company, per B. H. Parsons, dated New York, October 6th, 1917, and addressed to A. C. Douglass. The letter states that the reports of September 19th and September 24th by Mr. Douglass have been examined and that his "unit prices are a correct estimate, and that the work can be executed at these rates if properly directed by men of experience in this class of construction, with possibly the following exceptions:-

> Canal excavation in earth at $0.35 per cubic yard, and in rock at $1.56 per cubic yard, might both be conservatively increased about 10 per cent. Concrete lining for the canal bottom throughout and for the sloping sides where section is in earth, at $6.50 per cubic yard, we think should be increased to about $8.00 per cubic yard".

The authors state also that in view of the abnormal prices and of the precarious labor conditions, estimates must be regarded as subject to change and applied with caution accordingly.

A third letter is attached to the foregoing reports, signed by P. McGovern

& Company, per C. L. Perrin, dated New York, October 10th, 1917, and addressed to A. C. Douglass.

In this letter the following estimate is submitted:-

Rock excavation.....$1.75 per cubic yard.

Earth excavation.....$0.35 per cubic yard.

Concrete.....$8.50 per cubic yard.

Dredging.....$0.22 per cubic yard.

In addition, estimates for the tunnel construction are given in some detail. Generally speaking they are higher than the estimate submitted by Mr. Douglass.

[DRAFT]

Study of (1) Canal Bends, (2) Ice Skimmer, (3) Canal Losses.

R. D. Johnson.

A report dated July 30th, 1918, signed by R. D. Johnson, of R. D. Johnson and P. Wahlman, hydraulic engineers, of New York, was addressed to F. A. Gaby, Chief Engineer of The Hydro-Electric Power Commission.

Mr. Johnson's engineering qualifications have already been given on pages C-3 and C-4.

The report was made in accordance with written instructions by Mr. Gaby under date of May 27th, 1918, as follows:-

(Letterhead of Hydro-Electric Power Commission)

"TORONTO, May 27th, 1918.
H.G.A.

R. D. Johnson, Esq.,
60 Wall Street,
NEW YORK CITY.

Dear Sir:-

"With reference to your recent visit to Toronto and discussion with Mr. Acres of certain questions in connection with the Niagara Development, please note the following:-

"We desire you to look over the drawings forwarded under separate cover, and a list of which is attached.

"Will you kindly report under the following headings:-

(1) "Please look into the question of curves on the section between Montrose and the power house. These curves are now laid out for a 500 ft. radius.

(9-22)

under date of May 27th, 1920, as follows:-

(Letterhead of Klein-Edwards Power Corporation)

"Cleveland, May 27th, 1919.
W-4-W.

T. R. Francis, Esq.,
80 Vail Street,
New York City.

Dear Sir:-

"It is customary for your person visit to Toronto and Niagara with Mr. Lowe of certain questions in connection with the Niagara Development, please note the following:-

"I am desire you to have ready for inspection drawings and maps, and a list of bills to attached.

"Will you kindly report under the following headings:-

(1) "Please look into the question of moving on the eastern bottoms and the power house.
Those moving are now 140 ft. radius.

What radius would you suggest using, and how would you treat these curves?

(2) "Please submit a preliminary layout of intake at Chippawa, near Hog Island, along the lines discussed between Mr. Acres, Mr. Hogg and yourself. This proposal is, of course, to be considered only tentative and it is to secure your idea of how the problem should be attacked. We desire this information in connection with our proposed models to be tested at Niagara.

(3) "Please look over the proposed ice chute shown on drawing 7-6-26-d. We desire to obtain your suggestions in connection with this layout.

(4) "Will you kindly look over the curves showing losses in canal under various conditions? If you have any comments to make in connection with these, with reference to the advisability of lining with concrete, or otherwise, please let us have same".

Yours truly,

HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO.

(signed) "F. A. Gaby"
Chief Engineer."

The original document consists of nine pages of typewriting, accompanied by eleven drawings, consecutively numbered 59 to 69.

In Mr. Johnson's letter of transmittal, dated August 1st, 1918, he recommends that as soon as the dimensions and the desired degree of smoothness of the channel will have been fixed, a thorough study of the surges in the canal should be made. He draws attention to the fact that his study of surges under date of February 1st, 1917, was only applicable to a canal carrying 6,550 cubic feet per second of water, while the present report is based on 12,000 cubic feet per second.

The report is divided into three sections, namely -

Best Consideration of Bends,

(over)

Chas Pelton would [illegible] and buy work [illegible]
Great Lakes Control

(2) "Gibbons secured a preliminary [illegible] at Isthmus
on Stiggsons Lake Long Island, along the Lima Clearwater
Division B&O Route, Mr. Bing and [illegible]. This [illegible]
[illegible] to be completed early December and is [illegible]
to return [illegible] to be [illegible] to attend-
ed. The Bailey Mill Corporation is connecting [illegible]
[illegible] should be [illegible] by [illegible].

(3) "Gibbons back over the [illegible] Day Route [illegible]
on Sterling 4-6-60-4. Is desire to obtain [illegible]
Co connection with this Agent.

(4) "Will you kindly look over the [illegible]
Jensen is asked value [illegible] If you have any
necessary to make in connection with this reference
to the advisability of [illegible] with securing, or eliminating.
Please let me have same.

Yours truly,

C O P Y

MEMORANDUM-REQUESTED MORAL CONSIDERATION OF SECURITY.

(signed) "B. V. Bang"
Chief Engineer."

The original document consists of nine pages of typewritten [illegible]
by ulcer [illegible], unexceptionally accurate as to [illegible].

In Mr. Jamieson's letter of transmittal, dated August 1st, 1919, he re-
commends that we cash in the diamonds and the Revised Edition of Specifica-
of the Diamond will have been filed, a Township study of the region in the
usual alcohol we make. In three estimates he the last time his study of there
water dues of February 1st, 1917, the only [illegible] to a round [illegible] (30)
mile feet per second of water, while the present figure is [illegible] 12,000 mi-
lion feet [illegible].

The project is starting late there evening, namely -

Mail Communication at Block.

Proper Design of Ice Chute,

Accuracy and Adequacy of Loss Diagrams.

Bends.

Regarding the bends, the author presents two options, namely -

(1) A constant radius for each side of the canal of 150 feet, or,

(2) A centre line radius of 200 feet, with the sides of the canal concentric.

His opinion is that either of these methods would give better results than the 500-feet radius assumed by the Hydro-Electric Power Commission engineers. He suggests, further, that experiments should be made with radii as short as 50 feet with constant curvature.

At the conclusion of the discussion, the author makes the statement, - "It is not at all certain that some design radically different from those here suggested would not show less loss of head".

Ice Chute.

Under the heading "Ice Chute", the author discusses the Hydro-Electric Power Commission's plan entitled "Proposed Ice Skimmer at Forebay", and suggests a number of modifications which he considers as improvements. His suggestions are that a chute should be designed to run only partly full instead of completely full; that the entrance to the skimmer should be constructed for the full width of the canal; that a control gate should be made an integral

[illegible]

part of the skimmer platform, and of a heavy type operated by hoists; that the suggested tunnel under the bottom of the forebay should be replaced by a covered channel; and finally that the sides of the forebay should be straight.

Canal losses.

The author states that he has examined the diagrams of losses submitted to him "somewhat carefully", and that he found them to be correct enough for all practical purposes. After a discussion of methods of analysing the losses, he recommends the use of a concrete lining, retaining a width of 48 feet as previously designed for the rock cut with channeled sides, and he also recommends the deepening of the channel.

COPY

Study of Intake for 15,000 Cubic Feet per Second.

R. D. Johnson.

A report dated January 31st, 1919, signed by R. D. Johnson, of R. D. Johnson and P. Wahlman, hydraulic engineers, of New York, was addressed to Frederick A. Gaby, Chief Engineer of the Hydro-Electric Power Commission.

Mr. Johnson's engineering qualifications have already been given on pages C-3 and C-4.

The report was made in accordance with Mr. Gaby's verbal request of October 29th, 1918, and the original document consists of seventeen pages of typewriting, accompanied by eleven drawings, numbered 70 to 80 inclusive.

After discussing the generalities of the site of the Intake, Mr. Johnson outlines the following fundamental ideas which he kept in mind as a guide towards a correct design:-

1. As little interference as possible with the natural flow of the river,

2. Removal of the water from the bottom of the river into subterranean channels,

3. The interception by the Intake structure of a much greater width of the river bottom than that which bounds a cross sectional natural flow equal to the amount to be diverted,

4. The maintenance of the entrance velocity of the water at as low a value as practically possible,

5. Even diversion of the water,

6. The provision of two Intakes, having widely different characteristics, one of them adhering as closely as possible to the five principles above enumerated, the other designed as a complementary adjunct, without particular reference to these rigid requirements, but with the definite purpose of a relay completely adequate in itself for most of the time, and having characteristics which avoid, if possible, some of the difficulties not completely overcome by the more elaborate design.

The author submits general plans showing the outline of an Intake structure which offers a means of substantially fulfilling the foregoing requirements. This structure consists of six "draft distributors", 1,300 feet in length, and 100 feet apart, inclined upstream at an angle of about forty-five degrees to the direction of the current of the Niagara River. At the outer end of the distributors, for a length of 800 feet, inclined slots are provided for the admission of water from the bed of the river. At the shore end of the draft distributors, and at right angles to them, Mr. Johnson provides a series of piers, carrying a curtain wall and with stop log openings, so that the water of the Niagara River may flow directly into the Welland River channel without passing through the draft distributors.

The author concludes his report with a discussion of the probable friction losses through the structure.

Design of Intake for 15,000 Cubic Feet per Second.

R. D. Johnson.

A report dated March 1st, 1920, signed by R. D. Johnson, of R. D. Johnson and P. Wahlman, hydraulic engineers, of New York, was addressed to F. A. Gaby, Chief Engineer of the Hydro-Electric Power Commission.

Mr. Johnson's engineering qualifications have already been given on pages C-3 and C-4.

The report was made in accordance with a verbal understanding of October 30th, 1919, and the original document consists of twenty pages of typewriting, accompanied by ten drawings and diagrams, numbered 81 to 90 inclusive.

The author states that he has remodelled the design of the Intake, curtailing it as much as it is considered advisable according to the results of the experiments made during the summer of 1919 in the Dufferin Island channel. The design involves the development of a completely new theory of flow as referred to in Mr. Johnson's report of January 31st, 1919.

With the report the author submits a design of draft distributor or "gathering tube", 500 feet in length, and of very low cross section. Six of these tubes are required for a flow of 15,000 cubic feet per second. The body of the report contains a series of calculations illustrating the author's basis of design. He recommends building a small model of the mouthpiece of

[illegible]

his gathering tube as a basis for determining the required size.

In conclusion, Mr. Johnson makes the following suggestions relative to the general construction:-

"The top of the tubes are to be placed approximately flush "with the general level of the existing bottom of the river, and "whatever material is excavated between the tubes may as well not "be restored, thus leaving depressions in which any rubbish roll- "ing along the bottom would likely be deposited; but, in any case, "it is recommended to construct at least one such trench just up- "stream from the first gathering-tube. This should, preferably, "be smoothly lined with concrete to facilitate cleaning out when "filled up.

"It will be noted from the diagrams that the diffuser loss "is almost as great, at the assumed efficiency, as the entire fric- "tion, and it is desired to call especial attention to this, so "that due consideration will be given to the question of securing "a good efficiency of expansion, by spending enough money on the "length and smoothness of the diffuser. In other words, if loss of "head in this Intake is considered at all serious, the easiest way "to keep it down is to reduce the angle of flare of the diffuser, "at least to the point which is considered consistent with economy.

"It is considered desirable to be able to ascertain the nature "of the distribution of inflow which actually obtains, and, to this "end, it is suggested that suitable permanent piezometers be built "into several of the tubes, or, at least one of them, carrying the

"connecting pipes, embedded in the wall of the gathering tube,
"back to the head-block of the surface intake. The piezometer
"openings should be at least four in number at each station,
"arranged 90 degrees apart, and inter-connected to one of the
"transmitting pipes. Care should be exercised to have them
"placed flush and square with the inside surface of the tube.
"They should be spaced at least as close as 100 feet apart.

"Particular care should be given to shaping and finish-
"ing the guide vanes which form the partitions in the slots, as
"their influence upon the inflow of the water has been neglect-
"ed in the computation of the actual width of the slot. The
"surface should be finished particularly smooth and hard, and
"be carefully maintained true to form. It is possible that
"better results can be obtained by separately moulding and fin-
"ishing these vanes, leaving grooves in the sides of the slots
"into which they may afterwards be inserted and grouted".

Report on Queenston-Chippewa Development.

R. D. Johnson.

A report dated June 1st, 1920, was prepared by R. D. Johnson, of R. D. Johnson and P. Wahlman, hydraulic engineers, of New York. The original document contains twelve pages of typewriting, and is not accompanied by photographs or drawings.

Mr. Johnson's engineering qualifications have already been given on pages C-3 and C-4.

Mr. Johnson reviews the various phases of the studies and designs with which he had been intimately connected, and the report largely resolves itself into an encomium of the work of the Hydro-Electric Power Commission engineers.

The following quotations will give a general idea of the tenor of the report:-

"The Commission's engineers very evidently had in mind the adoption of a plan which would conform with the broad principles properly understood to be exemplified in a public undertaking for the benefit of the people, and the ultimate conservation of water with respect to the power rendered available, led to a more comprehensive layout than would probably have been attractive to private investors.....".

"Although the writer himself initially favored a tunnel for a capacity of 6,000 to 10,000 second feet, yet he is not inclined to hold this position with the capacity materially increased, as now contemplated".

"It is possible to make certain that no criticism of the present choice of waterway can be substantiated on any engineering basis".

"The value of a horsepower gained by additional excavation was determined to be considerably greater than the average horsepower produced by the whole development".

"It was found possible to fix the slope of the rock bottom, according to the best physical conditions, for carrying out the work of excavation without particular refinement in its relation to the hydraulic features".

"The question of surges ..... caused a good deal of concern until these phenomena were carefully studied ..... and it appears quite clear that enough information in this regard has been acquired so that safe operation will be provided in the Commission's plans".

"The methods which have been adopted (for the avoidance or disposal of ice) possess the double virtue of precluding the possibility of taking into the mouth of the canal any surface ice, and also of effectually removing any which may form on the canal itself".

"The model (intake) constructed according to the plan sub-

WALTER J. FRANCIS & Company

COPY FOR ENCLOSURE TO MR. J. ALLAN ROSE.

[illegible]

"Although the writer himself definitely favours a tunnel for a capacity of 6,000 to 10,000 persons daily, yet he is not insisting to this position with the capacity materially increased, as time continued.

"It is possible to make certain that no criticism of the [illegible] on points already mentioned may be substantiated on any engineering basis".

"The value of a bridge(sic) proved by satisfactory examination was intended to be sensationally greater than the revenue [illegible] shown produced by five cents investment".

"It was first [illegible] that the slope of the road bottom, especially in the most objectionable conditions, the capacity and the work of excavation without particular refinement in the pointing in the [illegible] tunnel".

"The question of making ..... seemed a good deal to ..... would those [illegible] materially affect ..... and it appears [illegible] that enough information in this regard has been supplied at this early stage [illegible] to the Commissioner's Office".

"The writer also [illegible] from the [illegible] of [illegible] possess the double virtue of [illegible] the possibility of [illegible] into the open at the tunnel any previous [illegible]".

"The tunnel [illegible] mentioned according to the plan [illegible]

"Although the writer himself definitely favours a tunnel for a capacity of 6,000 to 10,000 persons daily, yet he is not insisting to this position with the capacity materially increased, as time continued.

"It is possible to make certain that no criticism of the [illegible] on points already mentioned may be substantiated on any engineering basis".

"The value of a bridge(sic) proved by satisfactory examination was intended to be sensationally greater than the revenue [illegible] shown produced by five cents investment".

"It was first [illegible] that the slope of the road bottom, especially in the most objectionable conditions, the capacity and the work of excavation without particular refinement in the pointing in the [illegible] tunnel".

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"The writer also [illegible] from the [illegible] of [illegible] possess the double virtue of [illegible] the possibility of [illegible] into the open at the tunnel any previous [illegible]".

"The tunnel [illegible] mentioned according to the plan [illegible]

mitted by Johnson and Wahlman proved to behave exactly as the accepted theories anticipated, and this idea was accordingly adopted by the Commission as the best one up to date."

"The draft tubes ..... will certainly take their place in the vanguard of advancing attainment in this field of endeavor".

"The turbines themselves will be unsurpassed in all particulars by any similar apparatus in the world, combining many novel features of safety and convenience of operation, with the utmost conservation of the energy in the water which feeds them".

"The valves which will cut off the water when repairs to the turbines are necessary, will be of the most approved Johnson type, now recognized to be indispensable where the utmost safety and convenience of operation is desired".

"The Queenston-Chippewa Development, when completed, bids fair to furnish the best of material for the instruction and guidance of the students of hydraulic engineering as a magnificent exposition of the art, and a display of the utmost proficiency of its period in all particulars".

"The Inversion-Diffuse Derivement' when completed' like
occurrence of operation is Analog."

"The Inversion-Diffuse Derivement' when completed' like
cause of the existence of photocells activated by a modulated so-
urce is inside the part of protected the the Intensities and Dis-
played in all Derivatives."

Position of the end' and a display of the above Derivatives to Im-
proper Inversion-Diffuse Derivement' when completed' like
occurrence of operation is Analog."

"The Inversion-Diffuse Derivement' when completed' like
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urce is inside the part of protected the the Intensities and Dis-
played in all Derivatives."

Report on Chippawa Hydro-Electric Project.

Hugh L. Cooper & Company.

A letter of transmittal dated August 7th, 1920, submitted on August 14th, was followed by a report dated October 22nd, 1920. Both the letter and the report are signed by Hugh L. Cooper & Company, of New York, and were addressed to Sir Adam Beck, Chairman of the Hydro-Electric Power Commission of Ontario. The original letter of transmittal covered sixteen pages of typewriting, and consisted of a summary of the conclusions elaborated in the final report, the original of which contained twenty-four pages of typewriting, accompanied by drawings numbered 3436, 3439, 3440 and 3441.

The work done by Hugh L. Cooper & Company was under the general direction of Hugh L. Cooper, who was born in Minnesota in 1865, and was educated at the Rushford, Minn., High School. He commenced his engineering career with the Chicago Bridge & Iron Company in 1883, in which company he rose to the position of chief engineer and superintendent. From 1891 to the present date Mr. Cooper has been engaged in private practice, devoting himself more particularly to hydraulic engineering as applied to power development. He has designed and been connected with works totalling over a million horse power, and costing over a hundred million dollars, in the United States, Canada, Brazil and other countries. One of the principal plants with which Mr. Cooper has been connected is the well-known Hydro-Electric plant of the Mississippi River Power Com-

pany at Keokuk, Iowa. Mr. Cooper was elected a member of the American Society of Civil Engineers in 1905.

Following the engagement of Hugh L. Cooper & Company on April 22nd, 1920, Mr. Cooper wrote a letter to Mr. Acres outlining Mr. Cooper's understanding of the scope of his investigations. The letter reads:-

(Letterhead of Hugh L. Cooper & Company)

"NEW YORK,
May 1, 1920.

Mr. H. G. Acres,
Hydro-Electric Commission,
190 University Avenue,
TORONTO, Ontario.

COPY

Dear Sir:-

"With respect to the engineering work that we are to perform for you relating to your Chippawa plant, it will be well at this time to convey to you our understanding of the scope of this work in order that you may either approve this understanding or modify it as you desire. We are to make an examination and report on the project as follows:-

1. "We are to report on the capacity of the canal, intake system, forebay and penstocks, and power house, having in mind also such future changes of levels at the intake as will probably result from modifications of the present treaty between Great Britain and the United States regarding the final quantity of water that may be diverted at Niagara Falls for power purposes. Under this instruction we will express our views as to the practicability of the design you are building and its efficiency for the best use of 15,000 c.f.s. of water plus a minor allowance of 500 c.f.s. for debris disposal.

2. "We are to make a general check as to the strength and suitability of all the permanent structures enumerated in No. 1.

3. "We are to make such general survey and measure-

COPY

ments as will enable us to check your regular monthly estimates as to the accuracy and as to the amount of completed work on permanent structures at the time of our report. The extent of these measurements will be limited to the amount of work we find necessary to enable us to make a safe certificate respecting the same.

4. "We are to make a general report on the construction organization which report will include comments on the handling of the work up to date and recommendations as to the installation of additional machinery for the balance of the work, having in view the present high costs of labor and materials.

5. "We are to make an estimate of the time that will probably be required to place one unit and five units in commercial operation.

6. "We are to make an estimate as to the amount of money that will be needed to complete the plant up to five unit basis, and we will be guided in this estimate by the results obtained from Paragraph 3.

7. "We are to make such general investigations of your accounting system as to enable us to certify as to its efficiency and reliability.

8. "In making up our cost estimates we will use your figures for the cost of all real estate required.

"Will you kindly advise me here as to the correctness of the foregoing at your convenience, and oblige."

Yours very truly,

(signed) HUGH L. COOPER".

To this letter, Mr. Acres made the following reply:-

(Letterhead of Hydro-Electric Power Commission)

"TORONTO, Ont.
May 6th, 1920.

Hugh L. Cooper, Esq., Consulting Engineer,
101 Park Avenue,
NEW YORK, N.Y.

Dear Mr. Cooper:-

"I am in receipt of your two letters of the 1st

COPY

instant, and must apologize for the delay in answering the same, which was simply due to the fact that I was completely tied up with negotiations with the Labor Unions in connection with 1920 rates and working conditions.

"As to the formal proposition set forth in your letter, I may say personally that I think it covers the case as well as any more or less detailed specification of your function could do. To condense the proposition into a few words, what is required of you is to ascertain whether or not the Niagara job is sound in wind and limb. Further than this, if questions are asked, it would detract very greatly from the force of your findings if you were under the necessity of stating that you were not asked to report on this or that, or were not allowed access to such and such. As I have already stated, however, I think the method of procedure you have mapped out is sufficiently comprehensive to obviate any such embarrassing situation, and I think that Mr. Dexter Cooper would be well advised in proceeding along the lines indicated.

"Kind regards". Yours truly,

(signed) H. G. ACHESON".

Hugh L. Cooper & Company commenced their examinations on April 26th, 1920, and practically completed their investigation on August 17th, 1920.

As the letter of transmittal above referred to is mainly a summary of the conclusions of the report, the two will be dealt with together in the succeeding comments.

In a general way the conclusions of Hugh L. Cooper & Company cover the whole Chippewa project. In some cases the opinions and recommendations expressed are definite, while in other cases the references indicate that no special study was given to the detail in hand.

In general it is said,- "We find the general plan of the local canal system ..... to be the best that could have been adopted when the history of your project is fully understood".

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Regarding expenditures, the statement is made,- "We believe the expenditures ..... will be justified by the beneficial results which will accrue .....".

The capacity of the canal, according to the report, should be increased to 20,000 cubic feet per second, and the statement is added, "This increase in the use of water is possible without any appreciable loss of money for work thus far completed".

Of the upper level, the opinion is expressed that the elevation of the water surface at the point of diversion should be taken as elevation 558, and the report further states that the operating head will be 292 feet for a flow of 15,000 cubic feet per second, and 299 feet for a flow of 20,000 cubic feet per second, the greater head resulting from the use of a larger canal.

The report unqualifiedly states that the proposed intake design should be abandoned.

In the Welland River, as well as in the earth section of the canal, the use of a suction dredge instead of a dipper dredge is strongly recommended, for the stated reason that the saving thereby will be about $1,700,000. for a flow of 15,000 cubic feet per second, and about $2,600,000. for a flow of 20,000 cubic feet per second.

In regard to bridges, a general statement is included,- "That material savings in the cost of completed bridges can be made", but no further reference is made to the subject.

In referring to the work of the whirlpool section, the report says,- "Your engineers have used the best care possible", but a recommendation is

added that the stability of the whirlpool section should be tested hydrostatically before the lining work will have been completed.

For the purpose of the removal of floating ice accumulating in the canal, the report recommends the construction of a complete skimming system at a cost of about $500,000.

The report states that modifications are required in the forebay, the fact apparently having been overlooked that a distribution system had already been designed therefor.

In reference to the screen house, the report says,- "The general designs of screen house and penstock intakes are satisfactory. We will, however, recommend changes in the detail of the design in our general report". For reasons later stated, no recommendations were made.

In regard to penstocks, an observation is made similar to that concerning the screen house, but nothing definite is concluded.

The power house foundations are dealt with at some length, and further borings on the site are recommended. The sum of $250,000. is included in the report "to cover the contingency of a possible change from the present location".

The design of the turbines is approved.

The contract for the Johnson valves is "in the main satisfactory", but it is stated that special care should be devoted to inspection and details of design and shop work.

The report states that the design of the electrical apparatus has not been studied.

The power house substructure and superstructure are dealt with in a general way in the statement that "the general design of the power house indicates

a stable structure". The suggestion is made that a considerable saving might be effected in a re-design of the substructure.

Under the heading of "Organization", the report strongly recommends that the engineering and business management be located on the works at Niagara Falls, with complete authority over every detail.

In regard to the accounting system, the report states that it is "too intricate". The recommendation is made that all accounts should be audited by independent, certified public accountants every three months during the construction period. The further recommendation is made that an inventory should be completed for all tools, machinery and material, and that this inventory should be checked every ninety days.

It is recommended that a work-time schedule should be devised.

The organization of a complete system of fire protection is recommended.

A strong recommendation is made to put the laborers on a bonus or profit-sharing system of wages.

The report does not agree with the engineers of the Hydro-Electric Power Commission as to the discharging capacity of the entire water transmission system, particularly with reference to the rock section of the canal, and recommends increasing the slope of the floor of the canal so that the floor and the surface of the water when a volume of 15,000 cubic feet per second is flowing, are parallel.

The report states that there has been a difference of opinion between the engineers of the Hydro-Electric Power Commission and Hugh L. Cooper & Company, regarding the date at which the plant will be ready for operation. The

report also expresses the belief that the five units will not be installed, ready for commercial operation, before January 1st, 1923, and that "by good luck it may be possible to start operation with two units three months earlier than January 1st, 1923". The report states further that the controlling factors are,- first, the time in which the rock canal can be completed, and second, the time when the power house and its contents can be completed sufficiently to permit of commercial use.

It should be noted that at the conclusion of the report, the following statement is made,- "We have not called your attention to several other criticisms that we could also enumerate, for the reason we believe no practical good would result to you in our following such a course further".

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Report on Chippawa Hydro-Electric Project.

(Cost Estimates).

Hugh L. Cooper & Company.

A report dated August 7th, 1920, and signed by Hugh L. Cooper & Company, contains sixty-six pages of typewriting covering estimates of cost under three different "Cases", with alternatives in every case.

Case I is given as the estimate of cost of the project as designed by the Hydro-Electric Power Commission engineers wherein Hugh L. Cooper & Company's quantities and unit prices have been applied, using 15,000 cubic feet per second of water.

Case II is an estimate of cost of the project wherein Hugh L. Cooper & Company have introduced modifications in design, in accordance with their letter of transmittal dated August 7th, 1920, applied their quantities and unit prices, and used a flow of 15,000 cubic feet per second.

Case III is the same as Case II, but using 20,000 cubic feet per second.

All estimates are of the cost to complete by January 1st, 1923.

The following table gives the estimated cost of each Case, and alternative:-

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO MR. J. ALLAN ROSS.

(C-37)

Estimates of Cost.

	CASE I		CASE II		CASE III	
	5 Units	9 Units	5 Units	9 Units	5 Units	9 Units
	$	$	$	$	$	$
Intake	3,359,093	3,359,093	581,640	581,640	604,053	604,053
Welland River	1,831,434	1,831,434	644,995	1,170,357	1,289,071	1,920,170
Power Canal	22,912,732	22,912,732	22,864,311	22,487,182	25,685,602	26,022,763
Forebay	385,502	385,502	610,502	610,502	2,449,795	2,449,795
Screen House	1,582,823	1,777,398	1,549,071	1,743,646	2,193,122	2,493,122
Penstocks	1,173,985	1,672,573	1,173,985	1,672,573	1,364,766	2,533,850
Power House	5,116,005	8,020,424	5,116,005	8,020,424	6,125,120	10,582,987
Hydraulic Equip.	2,009,840	3,557,000	2,009,840	3,557,000	2,434,040	4,784,780
Electrical Equip.	4,752,160	8,417,360	4,752,160	8,417,360	5,668,460	11,166,260
Right-of-Way			Completed			
Bridges	1,534,023	1,534,023	1,534,023	1,534,023	1,534,023	1,534,023
Total	44,657,600	53,467,543	40,836,535	49,994,710	49,348,055	64,061,806
Engineering and Overhead at 8%	3,572,608	4,293,403	3,218,922	3,999,576	3,947,844	5,124,944
Total	48,230,208	57,960,946	43,455,457	53,994,287	53,295,899	69,186,751
Interest Charges	4,193,209	4,675,984	3,407,434	4,222,347	4,692,726	5,743,755
Total	52,423,418	62,636,931	46,862,892	58,216,635	57,988,626	74,930,506
Total Disbursements	14,000,000	14,000,000	14,000,000	14,000,000	14,000,000	14,000,000
GRAND TOTAL	66,423,418	76,636,931	60,862,892	72,216,735	71,988,626	88,930,506

Notes.

Cents are omitted in all cases.
Interest Charges are compounded semi-annually at 6-1/2 per cent.
Total Disbursements are to May 1st, 1920, plus interest compounded annually to January 31st, 1923.

Distribution of Stock.

The succeeding table gives a list of unit prices upon which the foregoing estimates of cost are based:-

Unit Prices for Estimates of Cost.

Hugh L. Cooper & Company.

August 7th. 1920.

ITEM	UNIT	INTAKE	WELLAND POWER RIVER	CANAL	FOREBAY	SCREEN HOUSE	PEN-STOCKS	POWER HOUSE	TESTING WHIRLPOOL SECTION
		$	$	$	$	$	$	$	$
Steel Sheet Piling	ton	125.00	0.70	-	-	-	-	-	-
Puddle	c.y.	1.20	-	(3.50 &	-	-	-	-	-
Rock Excavation	c.y.	3.50	-	(5.50	Complete	-	3.50	3.50	-
Earth Excavation	c.y.	.65	.70	1.10	Complete	-	-	-	-
Concrete Plain	c.y.	15.00	16.00	14.00	14.00	-	16.00	15.00	(*)20.00
								in C. Dams	
Concrete Reinforced	c.y.	40.00	-	40.00	-	40.00	40.00	32.00	-
								in Foundations	
Structural Steel	lb.	.10	-	.10	-	.07½ & .10	-	-	-
R.I. Spacers	lb.	.15	-	-	-	-	.11½	-	-
Earth Fill	c.y.	.60	-	-	-	-	-	-	-
Riprap	c.y.	1.00	1.00	-	-	3.00	3.00	-	(*) .60
Rock Lining		-	-	.15	-	-	-	-	-
Gate Operat. Mach.	lb.	-	-	.40	-	-	-	-	-
Rock Fill	c.y.	-	-	.15	-	1.50	-	-	-
Anchor Rods	lb.	-	-	.20	.20	-	-	-	-
Buildings, Super Str.	c.f.	-	-	-	-	.40	-	.40	-
Tunnel Rock	c.y.	-	-	-	-	-	10.00	-	-
Tail Race Excavation	c.y.	-	-	-	-	-	-	5.50	-
Earth for Piers	c.y.	.65	-	-	-	-	-	-	-
Suction Dredging		.45	-	.45	-	-	-	-	-
Caissons, Installing	Each	3000.00	-	-	-	-	-	-	-
" First Cost	Total	40000.00	-	-	-	-	-	-	-
Clipper Dredging	c.y.	-	-	.80	-	-	-	-	-
Steam Shoval		-	-	1.10	-	-	-	-	-

NOTE: (*) - These refer to Hugh L. Cooper & Company's figures resulting from their suggested changes in construction methods.

Report on Queenston-Chippewa Power Development.

Francis Lee Stuart and H. S. Kerbaugh.

A report dated September 30th, 1920, signed by Francis Lee Stuart and H. S. Kerbaugh, was addressed to Sir Adam Beck, Chairman of the Hydro-Electric Power Commission.

Mr. Stuart was born at Camden, S.C., in 1866, and graduated from the Engineering Institute at Washington, D.C. He spent a number of years in various positions from rodman to assistant engineer with railroads, and with the Nicaragua Canal Commission. In 1905 Mr. Stuart was appointed Chief Engineer of the Erie Railroad Company, and in this capacity carried out an extensive program of construction work for the Erie System, improving the elaborate terminals at Jersey City, including a series of four-track tunnels. In 1910 he was appointed Chief Engineer of the Baltimore & Ohio Railroad Company, and for five years had charge of general grade reduction work and a large construction program. Mr. Stuart entered into private practice in 1915 and acted as consulting engineer for various undertakings, and during the war was appointed Chairman of the Terminal Port Facilities Committee of the Council of National Defence, and of the War Industries Board. When the United States Government took over the railroads, he was appointed Chairman of the Budget Committee and passed on all plans and improvements of the railroads east of Chicago. He has a varied consulting practice in port and terminal

work, and particularly in railroad and industrial fields. Mr. Stuart became a member of the American Society of Civil Engineers in 1899, and was elected Vice-President in 1920. He is also a Past-President of the Society of Terminal Engineers.

Mr. Kerbaugh is known throughout the continent as having carried out some of the largest construction contracts in the United States. The following list gives some of the more important works which he has undertaken:- Sand Patch Tunnel, double track, through Appalachian Mountains; Magnolia Cut-off Improvement, B. & O. R.R. double track, including three tunnels and several million yards of heavy rock excavation; Curtis Bay Improvement, B. & O. R.R. - reinforced concrete pier, including piles and hydraulic dredgework; Buffalo - a large amount of hydraulic and dipper dredgework covering a period of five years; Kensico Dam - requiring the placing of one million cubic yards of heavy masonry; New York Highways - 300 miles of improved highway; Erie Canal - covering a period of five years; Susquehanna River - three stone arch bridges; Pennsylvania Railroad - a large amount of construction work involving expenditures of many millions of dollars; Panama Canal - adviser to Panama Canal Commission regarding the general plans for carrying out the construction. Mr. Kerbaugh owned and operated his own stone quarries, ballast quarries, commissaries, his own machine shops, and manufactured his own dynamite for some of his contracts.

The original report contained eleven pages of typewriting, and was made in accordance with the request of Sir Adam Beck that the authors should express their opinion and conclusions on the following features of the Queenston-

Chippawa undertaking, namely -

1. Suitability of the plant for construction programme proposed.

2. Possible dates of completion of the canal for generation of power by the first and second units at the Power House.

3. Probable cost to complete.

The authors deal with the undertaking, item by item, explaining the status and progress of the construction work.

Intake.

The authors approve of the proposed type of construction of the Intake, and state that it is not a controlling factor in any of the schedules of completion of the work.

Welland River Section.

The authors state that the Welland River Section is not a governing feature of the proposed schedule.

Gate House.

Regarding the Gate House, the authors say - "There are 25,000 cubic yards of concrete to place, some of which could be placed this Fall and the balance after March 15th, 1921, completing by the end of July, 1921".

COPY FOR ENCLOSURE TO SEC. G. dated July

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Penstocks.

In referring to the Penstocks, the authors state - "Penstocks have been contracted for, completely erected, by June 1st, 1921, and we see no reason why such schedule cannot be maintained".

Power House.

The authors reach the conclusion that the first unit in the Power House should be completely erected by May 15th, 1921.

Power Canal.

In discussing progress in the Power Canal, the authors go on to say - "The present shovel working in the Welland River Division should have excavated a cross section large enough to provide 3,000 cubic feet per second, required for units Nos. 1 and 2, early next Spring, and if necessary a dredge could help finish completing full cross section of 15,000 cubic feet per second by August, 1921".

The authors look upon the Canal as the controlling feature in the completion of the entire development for production of power on any given date, and they work out a schedule of approximate output of shovels required per month in earth and rock, to complete the canal for generating power by November 1st, 1921. They state that "the concrete schedule of 200,000 cubic yards of lining of canal and 120,000 cubic yards of concrete in control works, transition sections and walls, requires a schedule which will place the concrete as close behind

the units which excavate the sections to receive the lining, as it is practical. On account of the lateness of the season most of the concrete will have to be put in in 1921".

Crusher Plants.

The authors consider that it would be advantageous to the public if the available stone were crushed and a broad policy adopted by means of which this cheaply produced broken stone could be made to give an impetus to the "good roads" movement. They estimate that it is possible to provide 4,600,000 tons of broken stone which would give a return of $2,600,000. They recommend that an additional crushing plant with a capacity of 4,000 cubic yards per day be installed in addition to the existing one of 2,500 cubic yards per day capacity.

Equipment.

The authors state that sound judgment has been used in the selection of the equipment for the construction involved, and particularly in having provided 525-ton shovels with 8-yard dippers for work in the Canal, and modern standard gauge equipment for transportation needs.

Estimate of Cost.

The authors made the following estimate of cost to complete the power canal and installation of five units, and the first stage of the intake construction:-

Section	Cost to Aug. 26, '20	Remaining Cost	Grand Total
1-Intake	$ 259,578.	$ 1,340,003.	$ 1,599,581.
2-Welland River	387,568.	974,823.	1,362,391.
3-43A- Canal	7,071,023.	16,294,033.	23,365,056.
4-Forebay	794,154.	116,000.	910,154.
5-Screen House	97,794.	976,300.	1,074,094.
6-Penstocks	38,828.	1,052,310.	1,091,138.
7-Power House	437,701.	1,560,000.	1,997,701.
8-Hydraulic Mach'y	.....	1,646,000.	1,646,000.
9-Right-of-Way	1,000,000.	.....	1,000,000.
Miscellaneous	.....	200,000.	200,000.
Bridges	909,000.	1,091,000.	2,000,000.
	$10,995,646.	$25,250,469.	$36,246,115.

Contingencies 10%.....$ 3,624,611.

Total Net Cost.....$39,870,726.

Estimate of Cost of Superstructure and Electrical Equipment up to L.T. Bus.....$ 5,301,033.

Estimated residue value of Plant and Stores on hand to finish.....$ 4,700,000.

Total Investment.....$49,871,759.

Less: Possible Salvage recoverable - $4,000,000.
Receipts from Broken Stone - - $2,600,000. $ 6,600,000.

Total Net Investment.....$43,271,759.
Total Cost per H.P.....$ 173.08

The ultimate capacity of present plans contemplates the full use of 15,000 c.f.s., and the installation of a total of nine (9) Units producing 450,000 H.P., and will require when installed, $9,000,000. additional capital, making a total estimated cost of.....$52,271,759.
Total Cost per H.P.....$ 116.16

This estimate was based on the cost data of the work already done, and generally figured on basic prices as follows:-

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Earth excavation.....$ 0.70 per cubic yard,

Rock excavation.....$ 2.70 per cubic yard,

Plain concrete.....$14.50 per cubic yard,

Reinforced concrete.....$25.00 per cubic yard.

Attention is drawn to the fact that the total expenditure to the end of August, 1920, was $23,268,067.00 of which total $10,995,646.00 was the actual cost to August 26th, 1920, of the permanent work done on the project, while the balance is partly included in the items making up the "remaining cost", partly in the item of the cost of superstructure and electrical equipment, and partly in the estimate of the cost of the ultimate installation.

The authors discuss the possibility of increasing the capacity of the canal and conclude that by deepening the rock section a flow of 22,000 cubic feet per second might be obtained. On this basis of flow, they work out the following estimates for a plant of 660,000 horsepower capacity:-

Based on the present plans of five (5) Units for partial use of 15,000 c.f.s., will give 250,000 H.P., at an estimated cost of.....	$43,271,759.00	
Estimated Net Cost to deepen Rock Section less receipts for broken stone.....	$ 3,700,000.00	
	$46,971,759.00	
or Total Cost per H.P., 15,000 c.f.s. capacity.....		$ 175.08
Total Cost per H.P., 22,000 c.f.s. capacity.....		$ 187.69

The ultimate capacity of present plans contemplates the full use of 15,000 c.f.s., and the installation of a total of nine (9) Units, producing 450,000 H.P. and will require when installed, $9,000,000. additional capital, making a total estimated cost of.....$52,271,759.00

Estimated Net Cost to deepen Rock Section less receipts from broken stone.....$ 3,700,000.00

$55,971,759.00

or Total Cost per H.P., 15,000 c.f.s. capacity.....$ 116.16

Total Cost per H.P., 22,000 c.f.s. capacity.....$ 124.38

Increasing the capacity of the canal as a whole to 22,000 c.f.s. and putting in operation a total of twelve (12) Units, producing 660,000 H.P., will add $11,900,000. to the above cost of Nine (9) Units, making a total estimated cost of.....$67,871,759.00

or Total Cost per H.P.....$ 102.83

Comparison of cost per H.P. of various capacities until ultimate capacity of development is reached:

	15,000 c.f.s. Total Cap. 450,000 H.P.	22,000 c.f.s. Total Cap. 660,000 H.P.
250,000 H.P.	$173.08 per H.P.	$187.89 per H.P.
450,000 H.P.	$116.16 per H.P.	$124.38 per H.P.
660,000 H.P.	- - -	$102.82 per H.P.

Conclusion.

In conclusion, the authors make the following statements:-

"In general we have to advise you; first, that while this is a large undertaking it is in excellent shape for early completion; second, that all unknown conditions and uncertainties of construction have been eliminated; third, that the equipment is suitable; fourth that we think the peak of inefficiency of labor and the peak of prices of material and labor have been reached; and fifth, that with no unusual labor conditions, and with materials properly supplied, we consider the estimates of cost and dates of completion as feasible and dependable.

"The project and its purposes appeal to us in all its phases. The conception and design is simple and effective and the construction work is being carried out with proper present-day equipment and in an intelligent, capable way, with credit to all concerned".

Report on Lowering Water Elevations of Grass Island Pool.

Paul A. Schoellkopf.

A letter dated October 18th, 1920, signed by Paul A. Schoellkopf, President of The Niagara Falls Power Company, was addressed to the Hydro-Electric Power Commission for the attention of Sir Adam Beck, and dealt with the lowering of the water in the Grass Island Chippawa-Pool by diversions from the Niagara River.

The letter covers two pages of typewriting and was written in reply to a letter from the Commission under date of October 6th, 1920.

The Niagara Falls Power Company state that elevation 559.5 (N.S.P.Co. datum) at Chippawa is the lowest level of the pool under which they can safely and continuously divert the water allowed by Treaty for power purposes upon the American side of the Falls. They are of the opinion that this level should be maintained by such remedial works as would meet the approval of the respective Governments, and of the power developing interests which have based their works upon the above established levels.

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Report on Power Canal

Queenston-Chippewa Power Development.

R. S. Lea.

A report dated October 26th, 1920, and revised to December 7th, 1920, signed by R. S. Lea, of R. S. & W. S. Lea, consulting engineers, Montreal, was addressed to Sir Adam Beck, Chairman, Hydro-Electric Power Commission of Ontario.

Mr. Richard S. Lea, M.E., who was born in Prince Edward Island in 1866, graduated with honours in the civil engineering course of McGill University in 1890. For about twenty years Mr. Lea devoted himself to municipal practice in association with many well-known American engineers. He was for a time Professor of Civil Engineering at McGill, and he also took a special short course at the University of Cambridge. Later, he established himself in private practice with his brother, Mr. W. S. Lea, in Montreal, doing an extensive practice in municipal and consulting work, specializing more particularly in hydraulic problems. Mr. Lea is a member of The Engineering Institute of Canada, of the American Society of Civil Engineers, and of the Institution of Civil Engineers of Great Britain.

The original report contains nine pages of typewriting, and was made in accordance with written instructions under date of September 14th, 1920, to prepare a report on the following points:-

(A) A discussion of the water levels previously existing, and now and hereafter capable of being maintained on the Chippawa-Grass Island Pool, as a basis for establishing the water carrying capacity of the power canal.

(B) A discussion and report on the design of intake proposed by the engineers of the Commission, having particular reference to the merits, if any, it may have as applied to the special conditions it is designed to meet, and as compared with other types of intake which Mr. Lea might consider are suitable, having due regard to efficiency and capital cost.

(C) An opinion based on Mr. Lea's conclusions in regard to the above as to the water carrying capacity of the power canal as now designed.

Mr. Lea first discusses the river levels and the effect of the diversion of 15,000 cubic feet per second, and reaches the conclusion that the capacity of the canal should be based on an elevation of 559.5 at the Chippawa-Grass Island Pool.

The author then describes the proposed intake works, and concludes that the expenditure involved in the construction of the intake is justifiable in order to provide the best possible protection against the entrance of ice.

Based on a river level at Chippawa of 559.5, Mr. Lea states that he calculates the capacity of the canal to be 15,500 cubic feet per second, or with an elevation of 559.0, about 400 cubic feet per second less.

General Report.

Francis Lee Stuart and H. S. Kerbaugh.

A report dated December 13th, 1921, was made by Francis Lee Stuart and H. S. Kerbaugh, and addressed to Sir Adam Beck, K.B., Chairman, The Hydro-Electric Power Commission.

The engineering qualifications of Mr. Stuart and of Mr. Kerbaugh have already been stated.

The original report contains five pages of typewriting and was made in accordance with the request of Sir Adam Beck that the authors inspect the work on the Queenston-Chippawa development with the particular object of reporting on the quality of the work done, and the actual progress and cost in connection with the same.

The authors state:-

> "Briefly, we now find: (a) that the adequacy of the design and the quality of workmanship has come fully up to our expectations, and in the matter of quality has actually exceeded them; (b) that until the September 1st schedule was discontinued in July last, it had been maintained within a close margin, despite great and unforeseen difficulty; and (c) that the costs since September 1st, 1920, have overrun".

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The authors found that at the time of the discontinuance of the fast schedule in July, 1921, the earth excavation was ahead of schedule, while the rock excavation was behind the schedule. The shortage on rock excavation was ascribed to an unexpected change in the rock formation, and the late delivery of new steam shovels ordered in September, 1920. The steam shovels also failed to perform the work that was confidently expected of them, as compared with the electric shovels of the same size and general type.

The authors state that concrete work was also behind schedule in July owing to the failure of the original lining plants to function properly, and to the failure of the steam shovels to furnish the requisite working space in the rock cut.

In regard to Costs, Intangible Items, Quantities, Salvage, Power Capacity and Conclusion, the authors are so concise and definite that their statements are given verbatim, as follows:-

"Costs.

"Under this head we may state briefly at the outset that the major portion of the overrun on the September, 1920, estimate, may be ascribed, directly or indirectly, to the unexpected falling down of the steam shovels and canal lining plants. The excess cost directly chargeable against these factors is of minor significance as compared with the indirect costs for which they were responsible, arising out of such conditions as (a) obstruction to the operation of other plant; (b) irregular and congested operation of railway and dumping service; (c) additional burden on power, water, air, drilling, blasting, superin-

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tendence, engineering and other auxiliary services and overheads; and (d) the necessity of employing a working force at least 25% larger than would otherwise have been necessary.

"As to specific and ascertainable items of costs entering into the excess over the September, 1920 estimate, we find that they divide themselves into two general classes: (a) items of excess cost arising out of conditions which were justifiably, unforeseen and unexpected; and (b) items of excess cost arising out of conditions which were foreseen and appreciated from the beginning, but which were not seen in their true perspective as related to a 12 months' working schedule, which, to the best of our knowledge, was quite unprecedented.

"Under the head of wholly unforeseen or unknown items we may specify the following:-

(1) - Abnormal accidental contingencies.....	$1,000,000.00
(2) - Change in character of the rock.....	$2,500,000.00
(3) - Cement and sand.....	$ 550,000.00
(4) - Labor turnover.....	$ 613,000.00
(5) - Extra Plant.....	$1,331,487.00
(6) - Miscellaneous overheads.....	$1,552,347.92
TOTAL.....	$7,405,834.00

"Item No. 1 covers losses arising out of fires of purely electrical origin which occurred on the work during the past year. The circumstances surrounding these reverses were of a nature which did not previously come within the range of our experience.

"Item No. 2 covers our estimate of the excess costs arising out of the

rock work in the canal south of the whirlpool section. This rock was heavy on top and thinly stratified underneath, and was full of gas pockets which jammed the drills and left the walls full of ridges projecting out beyond the neat line. This condition enormously increased the cost of drilling, springing, blasting and trimming, apart altogether from the delays in shovel operation due to the imperfect breaking up of the rock. While there was sufficient finished rock cut at the north and upon which to base an estimate, the change in stratification and texture south of the whirlpool section, constituting two-thirds of the whole length of the canal, was such that the extensive preliminary exploration work did not furnish any evidence of the marked difference between the rock structure in the south section and the exposed rock in the north end of the canal.

"Item No. 3 covers the excess costs arising out of the unprecedented increase in the cost of cement for the year 1921 and the extra cost of purchasing and handling sand to make good the intensified concrete schedule which became necessary as a result of the failure of the original canal lining plants to function as designed.

"Item No. 4 is an item which we consider to be a very conservative estimate of the loss occasioned during the past year through labor turnover. The employment records in your construction office show that during this period 21,787 men were hired, and 15,766 either left or were discharged. This was a contingency we had no reason whatever to anticipate in September, 1920, when the beginning of the serious unemployment conditions which later developed, was plainly in evidence.

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"Item No. 5 covers various items of expenditure on plant which were the direct outcome of the unanticipated failure in respect of the steam excavating and canal lining plants. The largest individual item in this total was directly chargeable to the cost of re-designing and nearly doubling the number of lining plants as a result of the failure of the original plants and the failure of the steam excavating plant to make good the required schedule in rock.

"Item No. 6 covers various suspense items which were not or could not be incorporated in the unit costs at the time of our original investigation. With the exception of one item of accrued interest, however, all these costs were of a nature which could be considered as being included in our contingency item under normal circumstances.

"Under the head of ordinary contingency items of excess cost, may be specified the following:-

(a) "The actual operating loss on the steam shovels arising out of their failure to make good the required schedule.

"It was confidently expected that the greater speed and possibly greater power of these shovels would enable them to overcome the handicap of fuel cost, and equal, if not exceed, the records of the electric shovels in the matter of production. This assumption proved to be erroneous, but at the same time it may be stated that there was no other possible option open in the matter of providing a type of plant more suitable for the work to be done.

(b) "The repair costs for the year ending August 31st, 1921, were more than double the repair costs for the year preceding. It was upon the previous

year's records under this head that we necessarily had to base our judgment, and taking into consideration the large percentage of entirely new plant which was placed on the work during the past year, we felt ourselves justified in not anticipating any increase in the repair costs which could not have been covered by our contingency item.

(c) "A heavy charge for overtime arose out of the fact that the steam plant, in spite of its newness, was in constant need of repair, and also because the falling-off in the steam shovel production necessitated operation on Sundays and holidays at overtime rates to make good the required schedule. Not only this, but it required overtime operation of the electric excavating plant, and later of the concrete plant, to help make good the deficiency.

(d) "There was a large direct excess charge for labor which we had not anticipated and which, in our opinion, arose simply by reason of the fact that the unforeseen necessity of intensifying the working schedule, through plant failure, made it obligatory to employ a much greater number of men than would otherwise have been necessary. This latter condition would inevitably tend toward inefficiency and a loss of flexibility in the working force, which would fully account for this excess cost. Such a condition would apply generally throughout the whole working organization.

(e) "A large expenditure was incurred on various items of construction plant and material which it was necessary to purchase on short notice to meet conditions arising for the most part out of the nature of the rock, and the failure of the steam excavating and canal lining plants to operate as expected.

"The items under this head might be considered as being justifiably un-

foreseen, but we are including them under the head of ordinary contingencies simply because they would have been covered by our contingency item under any but extraordinary circumstances. The total of the above items we estimate as $3,600,000.00 of excess cost over the September, 1920 estimate."

"Intangible Items.

"There were also many conditions entering into the work during the past year which had a materially adverse effect on cost, but which could not be appraised in actual figures. Among such items might be mentioned the abnormal cost of freight and exchange and defective construction material. These conditions were the direct outcome of the war, and the abnormal freight tariffs and exchange charges which came into effect during the past year, constituted a very material factor in construction cost."

"Quantities.

"In the matter of the quantity of the various classes of materials moved and placed on the work, we find a very close agreement between the finished quantities and the quantities used in the September, 1920 estimate. In fact, if the unit prices used in that estimate are applied against the actual measured and finished quantities, there is an actual saving on our gross estimate of nearly $1,000,000.00.

"Salvage.

"We find that your engineers have written into the construction costs to date, 75% of the total plant cost, including not only the inflation of value during the war period, but a liberal allowance for ordinary depreciation. We are of the opinion that at least $1,200,000.00 may justifiably be added to the present book value of this plant."

"Power Capacity.

"In the September, 1920 estimate, the plans contemplated an ultimate production of 450,000 H.P. The high class workmanship and the refinements and accuracy of the construction features, which minimize friction, and are the factors controlling the rate of flow through the canal, will give an increased capacity, over that estimated in our report, of 50,000 H.P. or more."

"Conclusion.

"From our examination of the facts, we concluded that while the results which your engineers aimed at and worked for may have cost more than they or ourselves anticipated, there is no doubt in our minds, that in maintaining the high class of workmanship the extra money was well spent, and that the expenditure as a whole will be vindicated by the availability, in the public interest, of a large quantity of extra power at a price which will ultimately be in substantial agreement with the September, 1920 estimate."

Summary of Advisory Reports.

For the purposes of discussion, the advisory reports, or parts thereof, may be divided into three main classifications, namely, (1) those dealing with the intake, (2) those dealing with hydraulic conditions, and (3) those dealing with general features and costs. Of the two latter classifications, namely hydraulic conditions, and general features and costs, certain reports were obtained in the early stages of the work, while the remainder were not asked for until after the beginning of the year 1920 when the project was well advanced in the matter of field work and design.

Reports on the Intake.

The design of the Intake was first taken up in a conference between the engineers of the Hydro-Electric Power Commission, Professor R. B. Angus and Mr. Groat, at Pittsburgh. Following this conference the Intake Experiments of 1918 were carried out in the Dufferin Islands Channel. These experiments served to eliminate a fan-shaped Intake suggested by Mr. Groat, and to establish, as feasible, an Intake of approximately rectangular outline, and of a limited length and width, but they were not conclusive in the selection of type.

In October, 1918, Mr. R. D. Johnson was asked to present his ideas on the design of the Intake. He was furnished with the information already gather-

ed, and on the 31st of January, 1919, the Johnson "Study" was submitted.

The Hydro-Electric Commission then engaged Mr. Angus to take charge of the investigations of the type suggested by Johnson's "Study", and of another type devised by the engineers of the Hydro-Electric Power Commission. Again the Dufferin Islands model was used, and on November 5th, 1919, the experiments were concluded.

The second series of experiments proved the Johnson "Study" unnecessarily long, and demonstrated that both types would be completely satisfactory in their diversion of the necessary water from the Niagara River, with the complete exclusion of ice. Mr. Angus's record supported the "Hydro-Electric Power Commission Scheme", finding it effective, simple in design and economical in first cost.

On October 30th, 1919, Mr. Johnson was again consulted by the Hydro-Electric Power Commission, and on March 1st, 1920, he forwarded his "final design", remodelled and curtailed, "according to the result of the experiments of 1919". This "final design" would compare more favorably as regards first cost with the "Hydro-Electric Power Commission Scheme" than the design subjected to experimental test under Mr. Angus in the summer of 1919.

The "final design" consists of a series of piers carrying a deck and curtain wall. The piers are arranged in five groups providing three clear openings in each group, 18 feet wide and of adjustable height, with a maximum opening of 35 feet. These groups, in turn, are located between six "gathering tubes" spaced 100 feet apart, each tube being 675 feet long. The outer ends of the tubes are provided with slots for the entrance of the water for a length of 500

feet in each. At the inner end of each tube and downstream from the piers and curtain wall, a diffuser tube, 75 feet in length, is provided for spreading the flow uniformly into the Welland River.

In 1920 the "final design" was submitted to Messrs. Hugh L. Cooper & Company who strongly condemned it on the ground of unnecessary expense, and recommended in its place a type of fixed boom for diverting the ice away from the Welland River, at an estimated saving of two and three-quarter million dollars.

In the fall of 1920 Mr. R. S. Lea reported that in his opinion the expenditure on the proposed intake was entirely justifiable owing to the improved conditions it would create during the winter season.

In carrying out the construction of the Intake, the Hydro-Electric Power Commission has now undertaken the building of the piers and curtain wall referred to above, together with the diffuser tubes, downstream, and 100 feet of the gathering tubes upstream therefrom, with the intention of ultimately completing the gathering tubes, if found necessary.

Reports on Hydraulic Conditions.

The first advisory report on hydraulic conditions was made by Mr. Johnson on February 1st, 1917, who then dealt with the characteristics of the rock section of the canal, and made recommendations in regard to the shape of the canal section, and in regard to what elevation of the Chippawa Pool should be used as a basis for calculation, and finally in regard to provision for surges in the canal.

In April, 1917, Mr. Johnson made a second report, dealing with alternative

methods of carrying out an ultimate development of 900,000 horse power, with particular reference to open canals and pressure tunnels, with a recommendation in favor of the latter. This recommendation, however, was withdrawn in a later report of June 1st, 1920.

A third report, dated July 30th, 1917, by Mr. Johnson, goes somewhat more fully into the hydraulic characteristics of the canal, deals with ice conditions, and makes certain recommendations with regard thereto.

The elevation of the Chippewa Pool is discussed in reports by Messrs. Hugh L. Cooper & Company, on August 7th and October 22nd, 1920, by Mr. R. S. Lea on October 26th, 1920, and by the Niagara Falls Power Company, through Mr. Schoellkopf, in a letter dated October 18th, 1920.

The recommendations and discussions will be dealt with more fully in Chapter "D",- "Power Available".

Reports on General Features and Costs.

The first advisory reports with regard to cost, were obtained from Mr. Douglass in September, 1917, and dealt with estimates of unit costs for various kinds of construction work. Messrs. Hugh L. Cooper & Company submitted estimates of cost for various projects under date of August 7th, 1920. In their letter of transmittal of the same date, and in their final report, October 22nd, 1920, they criticise various phases of the designs, methods of construction and management, and make some recommendations in connection therewith.

Messrs. Francis Lee Stuart and H. S. Norbaugh, under date of September 30th, 1920, discussed the status of the work and prepared detailed estimates of

cost, and later, under date of December 13th, 1921, made a report on the general progress and condition of the development.

The following table gives in summarized form the principal recommendations of the advisory engineers, and the disposition thereof:-

Summary of Recommendations.

Author and Date.		Recommendation.	Disposition.
R. D. Johnson, February 1, 1917.	(a)	Canal section should be in proportion of 1 to 1 instead of 2 to 1.....	Adopted.
	(b)	For basis of calculations elevation 559 for Chippawa Pool is recommended.....	Adopted in part, but a higher elevation was used for fixing the effective capacity of the project.
	(c)	Provision for a rise of 6 feet in forebay due to surges....	Adopted.
R. D. Johnson, April 16, 1917.	(a)	Adoption of a pressure tunnel project.....	Not adopted, and at later date Mr. Johnson admits that canal project is preferable.
A. C. Douglass, September 19, 1917.) September 24, 1917.)	(a)	Estimates cost at $1.56 per cu. yd. for rock excavation.....	(These excavation figures were not adopted by the H.E.P.C. engineers for the reason that they were based on steam shovel practice instead of on electrical equipment.
	(b)	$0.35 per cu. yd. for earth excavation.....	
	(c)	$6.50 per cu. yd. for concrete.....	

Summary of Recommendations (Cont'd—#2).

Author and Date.	Recommendation.	Disposition.
R. D. Johnson, July 30, 1918.	(a) A constant radius for each side of canal at the bends	Adopted.
	(b) Ice chute to run partly full	Adopted.
	(c) Skimmer for full width of canal	Not adopted for present, but provision made for future installation if found advisable.
	(d) Concrete lining for canal with deeper excavation	Adopted.
R. D. Johnson, March 1, 1920.	(a) Recommendations for design of Intake	Partly adopted with provision for complete adoption in future.
R. D. Johnson, June 1, 1920.	(a) Approves canal project rather than tunnel	
Hugh L. Cooper & Company. August 7, 1920.) October 22, 1920.)	(a) Elevation of Chippawa Pool as 558.0 instead of 560.5	Not adopted.
	(b) Increase of slope of canal floor	Not adopted.
	(c) Skimming works in forebay	Not adopted for present, but provision made for future installation if found advisable.
	(d) Additional distribution system in forebay	Previously adopted.
	(e) Abandoning intake design and substituting fixed boom	Not adopted.
	(f) Bonus system for labor	Not adopted.
	(g) Whirlpool section should be tested with water	Not adopted.
	(h) Slopes of whirlpool section should be 2 to 1	Not adopted.
	(i) Plant should be increased to 20,000 cu. ft. per sec. capacity	Not adopted.

Summary of Recommendations (Cont'd--#3).

Author and Date.		Recommendation.	Disposition.
Stuart and Kerbaugh. September 30, 1920.	(a)	Additional crushing plant and sale of stone	Adopted in part.
P. S. Lea, October 26, 1920.	(a)	Elevation of pool should be taken at 559.5	Adopted at time, but later modified.

Walter J. Francis
Consulting Engineer.

Toronto, July 20th, 1922.